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SOUTH INDIAN FRUITS AND THEIR CULTURE

BY

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WITH ILLUSTRATIONS

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FOREWORD

BY

SIR S. V. RAMAMURTHY

K.C.I.E., C.I.E., M.A. (Cantab.), I.C.S.,

Chief Secretary to the Government of Madras.

South India has been long noted as a home of fruit. Mangoes, bananas and citrus together furnish fruit in all seasons and within reach of all. While they can be commercially cultivated in plantations, they can also be cultivated individually so that every house owner with a small plot of land attached to his house can grow one or more of the fruit trees and derive both pleasure and profit. Other fruit trees may be added to give variety.

Scientific cultivation of fruit received a fillip in Madras and other Provinces of India with the opening of a number of Fruit farms under the aegis of the Imperial, now Indian, Council of Agricultural Research. As Director of Agriculture, Madras, I selected the site for the farm at Kodur and selected also the Fruit Specialist in charge of it in the person of Mr. Naik whom I had met as an Assistant at the Lyallpur Fruit Farm. I am glad that under Mr. Naik's care, the Kodur Fruit Farm has made steady progress and that his experience has furnished the material for this book.

There can be no two opinions as to the value of this book. It is a book both on the theory and practice of fruit growing. As a text book, it will fill a sore need in our Agricultural Colleges. The general interest in fruit growing which has been steadily rising in the Province needs guidance, if it is to be of the maximum value to the people. Mr. Naik has given material which will help the student of fruit culture as well as individual and commercial growers.

I trust that the publication of this book will stimulate a rapid advance in scientific fruit culture in South India.

S. V. RAMAMURTHY.

April, 1947.

PREFACE

BY

Dr. G. S. CHEEMA

C.I.E., D.SC., I.A.S.,

Fruit Development Adviser

to the Govt. of India.

I have read with great interest the manuscript entitled "South Indian Fruits and Their Culture" written by Mr. K. C. Naik. I have critically gone through both the parts of this manuscript comprising nearly 18 chapters. The book gives precise details of various horticultural practices in vogue in South India, which would be given only by an author having first hand knowledge of the subject.

Mr. Naik has given a very impressive account of the fruit industry in South India. The horticultural situation, as portrayed by him, can well serve as a suitable basis for the planned development of the industry in this area. The author's accounts are all dealt with in a real practical manner. The descriptions of mango, banana and other regional fruits give a mass of detailed information which is useful for students and fruit growers alike. A book like this should find a place in every library attached to educational institutions and more particularly, every farm, orchard or agricultural college. I have no hesitation in saying that this book will prove a great addition to the horticultural literature in India and elsewhere.

Oct., 1948. G. S. CHEEMA

AUTHOR'S PREFACE

In sending out to the public this book on "South Indian Fruits and Their Culture" the author has attempted to meet a long standing demand in the region for a simple guide to the intelligent farming of a very important group of economic food crops of special value in human dietary. Reliable information on Indian fruits is scarce, and that relating to South Indian conditions is almost non-existent. This lacuna has impressed the author in the course of his research and advisory activities, and was brought particularly to the fore, when he was entrusted with the teaching of horticulture at the Agricultural College, Coimbatore in 1941. The duty to the students and the public impelled the compilation of all the available knowledge in a form easy of reference by the student, research worker and the fruit producer. The book has been modelled more or less in accordance with the horticultural syllabus of Madras and Andhra Universities. It embodies the experience gained by the author in the field of research, teaching and extension work, covering a period of over 24 years in five different provinces of India, of which over a dozen years were spent in South India. It aims to gather together in one text the matter contained in over 100 publications issued by the author on subjects of scientific and of popular interest, besides incorporating much that has been drawn from other workers and a large number of practical fruit growers.

It is not the intention of the author to lead the readers to imagine that this book contains a full account of the efforts made by all the fruit workers in South India, nor does the present work aim to guide everyone in all the varied aspects of a vastly complex science and art, which is fruit production. On the contrary, the author would wish this book to be looked upon as pointing the hazards in the facile trend among a section of the public for an over-simplification of fruit production methods and practices. No work of this kind can lay claim to perfection. Fruit research has so far been able to touch only the fringe of the subject, and much of what is known is sifted from the "rule of thumb" practices of numerous producers. To the specialist reader the information on several aspects may appear to be meagre or incomplete. This is bound to happen in any publication which is limited to the chornicling of actual experiences, observations or facts rather than to the reproduction of material mainly borrowed from exotic sources. The desire to impress the reader with a lot of untested facts of no material value to the region has been subordinated to that of emphasizing the vast field yet open for study, investigation and improvement. The wide-spread tendency in South India to look beyond the region for advice and guidance deserves to be curbed to as great an extent as that of some authors to generalise on the basis of limited experiences under a given set of conditions, quite foreign to those to which the advice is intended to apply. Blind imitation of exotic orchard practices has led in the past to considerable loss and an increasing feeling of frustration in the field of fruit production. Ill-conceived fruit introductions are also adding annually their undesirable effects. In no industry or avocation, an intelligent understanding of the principles and practices based either on experimental findings or on the sifting of practical experience of the producers, is considered more vital for success than in fruit industry. Risks and hazards are more serious in their effects in the farming of a primarily perennial crop as the fruit than in seasonal or agricultural crops. The producer with foresight endeavours to prevent and avoid the pitfalls from the very outset, and the present book is designed to assist him in that endeavour.

Although organised research on fruits is relatively in its infancy in South India, fruit-growing as an avocation or hobby has been carried on in the region from time immemorial. The individual attempts of countless growers, each following his own independent course, have served to add progressively to the fund of knowledge. It will be wrong to by-pass such experiences in favour of the advice from outside the region, for no other reason than that the advice is from a successful source or persons of some eminence. A variety or orchard practice does not become universally applicable merely because it has been found successful in some parts of the country or abroad. If it were so, it should be possible to produce all fruits under one standardised method all over the globe. It will be well if the South Indian producer recognises these basic facts and the need to shape his orchard entirely in the light of knowledge and experience gained in his own site or from the observations and findings of research workers in his own region. The aim of this book is to make a critical examination of what has been achieved through research on South Indian fruits and to bring together scattered fragments of knowledge from the practical producers within the region. At the present stage of our fruit development, it is considered useful to sum up the available knowledge for the benefit of all interested in the subject; and this is what has been attempted. Fruit research is gaining an increasing momentum in South India, and additional information will continue to become available as time passes by. The book serves to meet only the present demand, and shall have to be occasionally brought up-to-date in future.

The Fruit producer being generally given to specialisation of some sort or other, it often happens that his interests extend to only one or a few fruits or to only certain aspects of fruit production. To meet such a contingency and even at the risk of some amount of repetition, every chapter of the book has been made self-contained to the extent possible. Notwithstanding the likely criticism that, repetition of references to literature is an avoidable feature, that feature has, therefore, been allowed to stand with a view to cater to the readers of diverse tastes. The list of references is further restricted to those dealing with South Indian fruits, except when outside references were considered inevitable.

The publication of this book has been rendered possible by the ready and willing assistance given by a large number of the author's colleagues and friends. In particular, the author wishes to acknowledge with thanks the valuable help given in the preparation of a very considerable number of photographs found in this book by Mr. C. K. Anavema Reddy, M.A., M.Sc., of most of the sketches by Mrs. Hyma A. Reddy, M.A., M.Sc., of the design for the cover page by Mr. G. Aranha of the Indian Audit Department, and of certain sketches on propagation by Mr. M. Mohan Rao, M.Sc., Propagation Superintendent, Cinchona Department, Madras. The author is also indebted to Mr. K. S. Venkataramani, M.Sc., of the University Botany Laboratory, Madras for help in the preparation of a part of the section dealing with banana classification and to Mr. U. Narasinga Rao, Assistant Fruit Specialist, Coonoor for recasting much of the chapter on "Hill Fruits." The Provincial Marketing Officer, Madras, the Government Entomologist and the Government Mycologist, Coimbatore have furnished valuable material from time to time, and which have been incorporated in the book. Messrs. V. N. Madhava Rao and K. Fazlullah Khan of the Madras Fruit Section have also gone carefully through parts of the manuscript relating to the subjects of interest to them and have made several valuable suggestions. The author has drawn freely from the published and unpublished material contained in the monthly and annual reports and other publications of the various fruit stations and fruit schemes financed by the Government of Madras and the Indian (former Imperial) Council of Agricultural Research, in South India. To all these also, the author is deeply indebted.

Madras, K. C. NAIK.
March, 1948.

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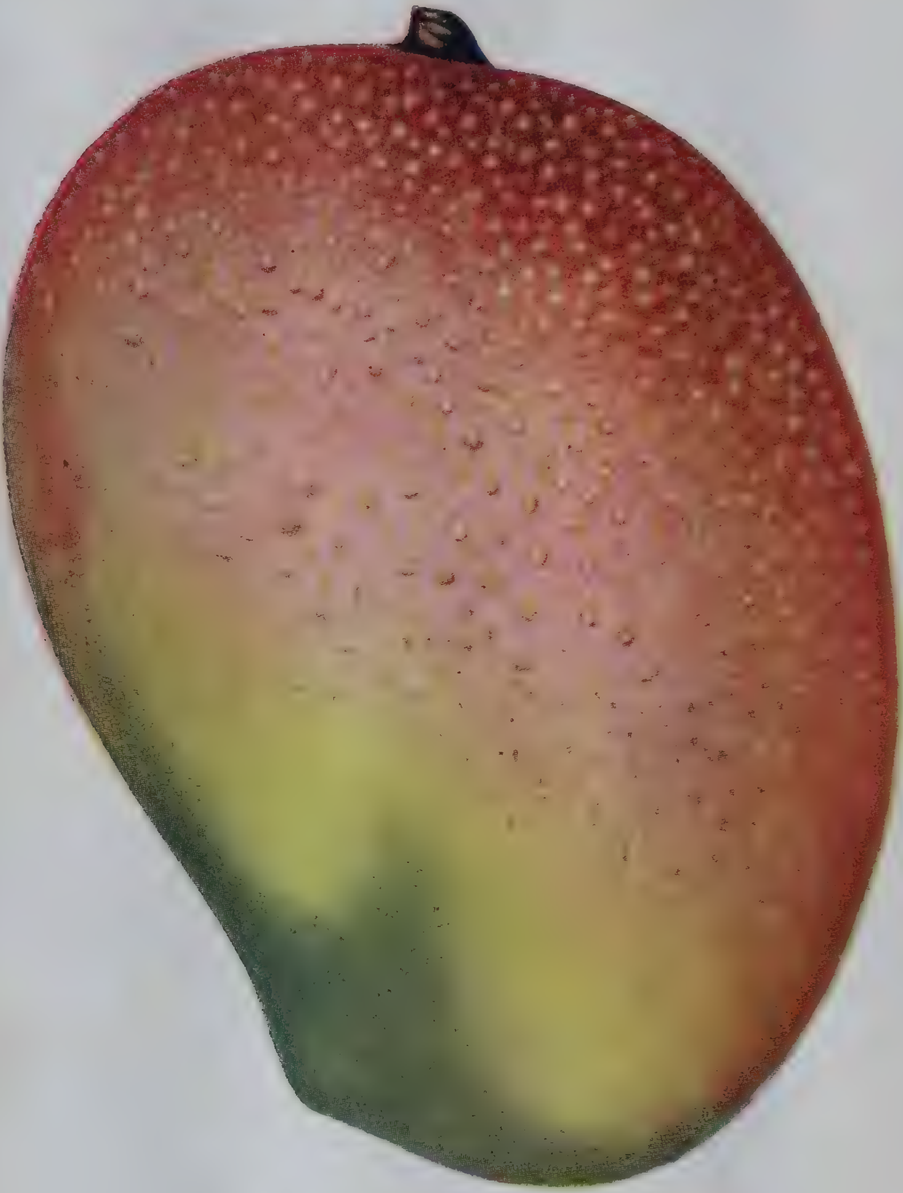

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PART I

CHAPTER I

IMPORTANCE OF FRUIT INDUSTRY IN SOUTH INDIA

ITS POSITION AND POSSIBILITIES

Fruit-growing or pomology is recognised to be among the most fascinating of rural avocations. People follow the art of fruit production not only to make a living and to earn more from one's land and labour than from other methods of farming, but also to derive much that cannot be measured in terms of money. By promoting fruit production one is endeavouring to contribute in a measure to the aesthetic side of rural and home life, embellish the landscape effect, and thereby sweeten and redeem life to an extent greater than by many other agencies. Fostering and improving fruit production is, therefore, claimed to fall in line with the forces that generally make for social well-being of mankind.

In its economic aspects, it is also difficult to over-estimate the importance of fruit production to a nation, since it is so interwoven with the life of the people. From its original phase as merely a source of one type of food, fruit production has now developed with its numerous ramifications to be a very important source of wealth and international trade, in many lands. In the United States of America fruit is the leading exportable commodity. In Palestine, Spain, Japan, Italy, Brazil, South Africa and Australia also fruit is one of the leading sources of wealth and trade. In its money value, in the large number of workers engaged on it, in its ability to distribute purchasing power, in the impetus it gives for industrialisation by fostering several auxiliary industries, in attracting population to the land and in feeding the people with a most healthful and essential food, fruit-growing is to be deemed as a major and essential plank for the economic progress and security of every country.

It is now universally recognised that man cannot live on agricultural produce alone. He requires a variety in diet and supplementary foods of certain health-giving properties as the fruit. Fruits are in the class of protective foods, in that they help to protect the human body against ill-health by supplying the valuable vitamins. They are important sources of certain mineral salts, lack of which in human dietary leads to disturbances of metabolism and of health. The pectin contained in several fruits is now known to stimulate intestinal activity and promote bowel action. The cellulose in fruits adds bulk to foods, and this serves also therefore the aforestated purpose without producing any friction or irritation in the intestines. Regular consumption of fruits has accordingly been considered necessary to mitigate chronic constipation. Many crisp and tart fruits are claimed to stimulate circulation in gums and freshen the teeth and are among the best alkaline reacting foods. Some fruits are also valuable medicinal agents. Above all, most fruits are tempting, palatable, appetizing and enjoyable foods. From the nutritive and health point of view, no less than from economic considerations, fruits indeed play a valuable role in the life of every nation, so much so that they are now deemed to be Nature's best device for keeping mankind happy and healthy.

The importance is heightened when one examines the yield of food secured through fruit farming. As against the maximum of 8,000 lbs. of paddy per acre in a year from the best of lands, a fruit like the banana is capable of yielding over 20,000 lbs. of fruit from the same extent of land. Many other fruits like mango, papaya, pineapple, jack and grape are capable of yielding almost as high or even larger outturns per acre per annum from fully established and well kept orchards. In a densely populated region as South India, where cultivable land is limited, fruits therefore provide the best means of exploiting the land for securing maximum food per unit area.

According to an American authority an individual requires roughly 1,400,000 calories of food per year. On this basis each person would have to cultivate about 1.45 acres of wheat, or 0.09 acre of banana or 0.5 acre of mango for satisfying his or her needs. In other words, mango produces about 29 times the food energy per unit area produced by wheat, while banana produces much more. These serve to emphasise the value of fruit production in augmenting our food resources.

Taking the province of Madras alone, it has been worked out that the area under fruits represents roughly 1.1 per cent. of the total cropped area in that province. On the other hand, the total income from all cultivated crops in the province is estimated at 350 crores of rupees, while that from fruit alone is about 216 million rupees, which works out to 7.4 per cent. of the province's crop wealth. These show that fruits yield six to seven times the income from agricultural crops. Receipts exceeding Rs. 10,000 per year per acre from some well kept orchards are not uncommon in South India. On the score that fruits yield more money from land, their extension is, therefore, justified.

As a mother of several industries like canning, dehydration, essential oils, beverage, jam, pickles, vinegar, candies, preserves etc., fruit-growing is worthy to rank high in the nation's wealth-promoting avocations.

Most of the agricultural crops are seasonal and the ryot requires therefore other diversified avocations to engage himself profitably in slack periods. Unlike general agricultural farming, fruit-growing provides little leisure and no slack periods. The diversification and all-the-year-round work which fruit-growing provides are especially and obviously necessary to the social and economic improvement of South India.

Fruit-growing not only demands some intelligence but it also develops and promotes intelligence by the practice of it. The ever-recurring and ever-changing problems of perennial crop culture are a constant challenge to the ability and mental equipment of the producers.

Summarising the advantages of fruit farming, it may be stated that it supplies better food, higher income, all-the-year-round occupation, a diversified system of living, an aesthetic touch to the life and living, and some stimulus to promote intelligence. It promotes the development of natural resources, yields higher returns from land, enhances the land values, creates a better purchasing power among the people, and consequently adds to the general prosperity. On these various grounds, the ancient pastoral and agricultural farming has gradually changed, giving rise to fruit-growing as the perfect, health-giving, industrialised and aesthetic profession in many countries of the world. It has been said with no small amount of justification that the pace of fruit development provides an indication of the pace of civilization. Hunting and fishing have usually been associated with the pre-medieval life of savagery; pastoral life and cruder forms of agriculture with the next stage of semi-barbarous or pre-civilised periods; and fruit-growing with the higher, more intellectual, skilled and technical form of utilisation of land, characteristic of the highest form of civilised life.

Nature has richly endowed South India with a fruit wealth of great and almost unrivalled interest, diversity and character. For a region that can produce good crop yields from such distantly related fruits as the mango and mangosteen, guava and grapevine, apple and *amla,* jack and *jujube,* banana and bread-fruit, lime and litchi, sapota and sweet orange, lemon and langsat, passion fruit and palmyra, persimmon and papaya, melons and mandarins, cashew and custard apple, plum and pomegranate, the word remarkable may perhaps be a weak expression. The unique distinction of the region to produce more than one sizeable crop of fruits from apples, grape and mangoes in a year conveys only a partial idea of the scope for fruit development in this part of the country. That even without the stimulus of any large-scale and long-standing organised attempts, South India has come to lead most of the country in the production of several fruits such as the mango, banana, cashew, citrus fruits, mangosteen, avocado, jack, mulberry etc., and in its ability to place many fruits in off-seasons and for the longest periods of the year, as well as in yielding record crops at the lowest cost of production in numerous rain-fed groves, establish the fact that the leadership should rightly belong to the region in all times to come. More: South India has everything in its favour to develop fruit production, such as to be an inspiration even to the rest of the world.

PRESENT DRAWBACKS

Notwithstanding the fact that South India has grown fruits from time immemorial, fruits account for only about one per cent. of the total cropped area in 1943-44. Most of the orchards are still of a pseudo-commercial type, as distinct from the highly organised fruit production industries in many parts of the world. A vast majority of the South Indian fruit producers find in fruit farming a highly speculative enterprise. To only a negligible few is orcharding a whole-time occupation. Absentee orchard ownership being the predominant feature, practical fruit-growing is largely based on "hit or miss" methods of the uninterested and untrained servant class. There is therefore too much of complacency in the event of crop failures or poor harvests, which are too frequent to foster progress. In contrast with the well-planned commercial orchards of many other lands, the South Indian fruit plantations appear in general to be veritable fruit tree museums, planted to a host of varieties and kinds, plants of which are obtained from a multitude of generally questionable sources with no guarantee of their quality, parentage or performance and with no assurance of their suitability to the sites earmarked for them. Planting of the wrong variety or in the wrong district or site are common features. Even a casual visitor to South Indian fruit markets will not fail to be struck with the wide variety of fruits displayed and the predominantly poor and unstandardised produce offered for sale to the consumers, generally at high prices. If statisticians were to turn their attention to determine the extent of loss due to the establishment and maintenance of ill-conceived, ill-planned and indifferently stocked orchards, the figures would indeed be astronomical. The huge loss due to the upkeep of marginal or non-yielding trees as well as due to uninterrupted process of soil erosion in orchards, is but a part of the price that South India pays for neglect and ignorance on the part of the producers.

The South Indian fruit grower is yet to recognise the basic truth that the most careful orchardist cannot achieve success with inherently poor plants and with varieties unsuited by nature to the site, even if he gives the closest attention to all other factors of production. As the cost of plants is the smallest item in orcharding, it is illogical to take chances in purchasing the plants on the score of misguided economy. None can make an inherently inferior tree yield profitable crops, any more than one can make a wild seedling tree of inferior fruit-bearing type to yield high quality table fruits similar to those of cultivated superior sorts. The grower's first and foremost duty should, therefore, be to lay the foundation for orchard efficiency by stocking the orchard with cent. per cent. inherently fruitful trees of such varieties as are suitable to the region and site.

Orchard efficiency studies conducted by the author in some orchards of South India have conclusively brought out the amazing fact that, even in what are usually classed as remunerative plantations of mango and sweet oranges, it was only a very few trees that yielded good crops regularly, a larger number gave good crops at varied intervals of time, while the largest number comprised of individuals which bore uneconomic crops or no crops at all for a succession of years. If this be the picture of profitable orchards, one may well visualise the condition of those countless groves of South India which are definitely not prosperous or paying to the owners. The implications of these revelations are that, even in the few fortunately placed orchards, the producers are spending every year a large part of the receipts from a very few of their good-yielding trees, on the maintenance of a vast majority of useless trees growing alongside and around. In effect, this means a colossal waste of money and efforts. The progress and prosperity of South Indian fruit industry lies, therefore, in having no tree in the orchards, which is inherently unproductive, shy-bearer or irregular-cropper, or one which yields poor quality fruits. An inefficient orchard begets more of its kind through the present widespread practice of indiscriminate propagation methods ; and this has to be checked if the downward march of the industry is to be prevented. By doing so, we can increase production without increasing costs of production. Therein lies one sure way of reducing the cost of fruit to the consumer.

In this all-important work of stocking the South Indian orchards with cent. per cent. inherently profitable trees and varieties, the fruit nursery industry has a big responsibility. The fruit nurseries should strive to be the legitimate and proper guides to fruit growers, as they actually are in some lands. If on the other hand, they have merely an eye on quick profits and on clearing their stock, regardless of the larger interests of the fruit industry, we have thereby a most potent means of bringing about progressive deterioration in our fruit and orchard wealth. Many allegations have been made in the past that some fruit nurserymen not only fail in their duty of selecting varieties and parents, but even resort to questionable practices of selling plants under wrong names and with false and exaggerated claims. Many nursery firms do not even have under their control any selected batch of parent trees, while some do not possess any tree at all fit for propagation. So long as a single unscrupulous nurseryman is allowed to ply his nefarious trade, we have therein a means of adding to the uncertainty in fruit farming, of augmenting the loss to a vast body of growers, and consequently, adding to the cost and scarcity of fruit.

Fruit nursery is wellknown to be a paying proposition and therefore may attract all types of persons. An elementary knowledge of grafting is all the qualification that is deemed necessary, and this can be acquired in a few weeks at the most. The clientele comprises of the unwary and generally untrained public, who cannot ordinarily detect that they have been duped, till the trees purchased by them bear fruit, after years of waiting, toil and expense. There is no law to punish the offenders, and therefore scope always exists for anyone to try his hand at making some money at the growers' expense. It is, therefore, high time that this lure to a business on which depends the prosperity of the fruit industry, is curbed or regulated. The enlightened growers and the reputed nurserymen should show unity of action and purpose in rooting out the existing evils, whenever and in whatever form they may be found.

Even under the best of management and with the best of plant material, success in fruit-growing cannot always be assured. With a perennial crop like the fruit, mistakes committed once cannot always be rectified, sometimes not even throughout the long life of the plantation. From the selection of site to the stage of harvest, there are numerous orchard operations, which demand a knowledge of the tree habit and growth, so as to be able to assess the tree requirements correctly and to adopt the right measures and cultural practices. So far, the South Indian fruit growing methods have been largely carried on by "trial and error" methods, by a vast body of men, each pursuing his own course of action. The success of a few here and a few there prompted many to take to the farming of fruit, but without any attempt to analyse the pre-requisites or to understand them. Pioneer fruit-growing and ill-planned or spontaneous fruit development as in South India are always hurried, blundering and erring. We would be wrong if from these early faltering steps we conclude that fruit-growing itself is full of risks. It will be an act of foresight if we help the faltering steps to be planted on the firm ground of technical understanding; and through this stabilisation proceed to build for the future.

POSSIBILITIES

The traditional saying that, "He who plants pears plants for his heirs" emphasizes the long term nature of perennial pomology, under which all tree fruits of South India are to be grouped, implying at the same time the speculative nature of tree fruit culture. During its long life, orchards must necessarily face prosperity and depression periods—the latter eating up the profits gained in the former period. Efficiency in orchard planning, planting and management are essential, if the periodical losses are to be avoided or mitigated. Efficiency is acquired both by education and experience. Research aims to counter the adverse influences of season on fruit production and to devise methods to reduce crop failures and to promote optimum yields at the lowest production costs. Research and experience also point out the means to adjust the adverse elemental effects to the best advantage of the producer. Without a basic knowledge of the methods of fruit production and a desire to constantly expand that knowledge by keeping in contact with the results of research, fruit production is bound to be a gamble. The passing fads and opinionated advice of pioneer days can only add to the risks and hazards. Unlike in seasonal crops, and generally speaking, there is little or no chance for the tree fruit grower even to rectify his errors when once they are detected. In no other rural avocation, therefore, has the completely informed individual a really definite advantage over the rest than in fruit production, and this is regardless of what situation may arise.

Opinion has been expressed that in some fruits at least, South Indian production has almost reached the saturation point ; and therefore, further extension of orchards may only serve to accentuate overproduction. This view is not dissimilar to the one which can be advanced when any new fruit is introduced for the first time to a region, to the effect that it would automatically create a surplus to the existing demand. If the local demand be the sole criterion for fixing the targets for future production, California would have continued to be the producer of staple crops such as grains, as it was about half a century ago, when that State switched on to commercial fruit production. Instead of being frustrated and disappointed at the unsatisfactory marketing situation which developed in the early stages of fruit development in California, when some growers experienced prices even lower than their costs of production, the California growers were impelled to increased efforts to efficiencise production and marketing methods. The result is that, within the life time of many persons still alive, there has been a revolutionary change, such that has contributed to a degree of well-being and general prosperity without a parallel in any the picture becomes more encouraging and definitely one-h r. Years ago, a renowned explorer and fruit worker of in th , Wilson Popenoe, had predicted that people in the Temper- tha zone must look more and more to the Tropical East to supple- th t their fruit resources. In the vast changes in the world's fruit en ture and policies and in the political sphere that have been and v e taking place, the premier role that South India has to play may ecome gradually clear. The region can usefully cherish the ideal of becoming the leading fruit producing and supplying region in the East, to achieve which it has abundant opportunities and resources, given a planned move and the same is implemented with sustained vigour.

List of References

1. Famine Inquiry Commission Report, 1945.
2. Hodgson, Robert W.—The Fruit Growing Possibilities of Patiala State, India, Vol. IV, No. 7, 1936.
3. Naik, K. C.—Fruit Growing in the Plains, Current Science, Vol. IV, No. 7, 1936.
4. ,, Fruit Growing as a National Industry, The Gardener, Vol. I, No. 4, 1937.
5. ,, Orchard Efficiency Analyses in Mango and Sweet Oranges, Madras Agricultural Journal, March, 1940.
6. ,, Plant Selection in Orchard Economics, The Gardener, Vol. 1, No. 4, 1938.
7. ,, The Choicest Fruits of India, Gardener, Vol. 11, No. 2, 1938.
8. ,, Indian Fruit Industry, The Times (London)—Trade and Engineering, April, 1939.
9. ,, Fruit Growing in South Kanara, Geographical Magazine, Madras, 1938.
10. ,, Eat More Fruit, Madras Agricultural Journal, Vol. XXXII, Nos. 5, 6, 7, 1941.
11. ,, Some Special Features of South Indian Horticulture, Indian Journal of Horticulture, Vol. 1, No. 1, 1943.
12. ,, Government Fruit Stations—What They Stand For? Villagers' Calendar and Guide, Madras, 1944.
13. ,, Value of Fruit Diets, Villagers' Calendar and Guide, Madras, 1944.
14. ,, Fruit Production in South India, *Vyavasayi*, Madras, 1946; and Souvenir of the All-India Khadi & Swadeshi Exhibition, Madras, 1947.
15. ,, Fruit Industry in Relation to National Health and Prosperity—Hand Book—Swadeshi, Guide & Directory, Madras, 1937-38.
16. ,, Industrial Utilization of Agricultural Products in India, Journal of the United Provinces Fruit Development Board, Vol. III, No. 11, 1940.
17. ,, Importance of Backyard Gardening with General Cultural Hints, Madras Agri. Dept. Leaflet Nos. 104, 105, 106, 108, 109, 110, 111 & 112, 1943.
18. Popenoe, Wilson — Manual of Tropical & Sub-Tropical Fruits, The Macmillan Co., New York, 1920.

CHAPTER II

CLIMATE AND SOILS

The success of fruit production is dependent on the favourable combination of certain natural factors, among which climate and soil are the most important. The former includes several basic environmental elements such as temperature, rainfall, atmospheric humidity, wind, hail and light, while the latter covers such factors as soil moisture supply, texture, chemical composition and temperature of the soil. Each of these has a determining influence on the growth and performance of fruit trees, so that the delineation of the fruit growing zones is made on a consideration of all these factors. For an accurate appraisal of the fruit growing possibilities of any site or zone, the growers are required to possess an idea of the influences exerted by each of these environmental factors, failing which their attempts in the field of fruit production will best be a trial, in the course of which only a few may succeed. Since a trial with a perennial crop like the fruit is an expensive and time-taking affair, besides uncertain of results, few can afford such ventures, which are therefore legitimately left to the fruit research stations in all countries. Unfortunately, so far as South India is concerned, fruit research being yet in its initial stages of progress, there is not a great deal of information available such that would enable to lay down the best variety or kind of fruit to each site or zone, or the optimum orchard practice for each fruit in all the areas. However, work done elsewhere has furnished useful knowledge on the basis of which certain broad generalisations can be made, supplemented by the experiences gained in the fruit research stations and from numerous private orchardists' attempts in South India.

CLIMATE AND ITS INFLUENCES ON FRUIT PRODUCTION

A. *Temperature* :—Every fruit variety has a fairly well defined range of temperatures to which it is tolerant, or below which the plants of that variety are liable to be injured to a more or less extent. Some fruits like apple and pear for instance, will only grow and crop when planted on sites enjoying a cool climate, sufficient to induce the trees to shed their leaves for a period of the year. On the other hand, some fruits like the mango and banana require a long growing season, without any forcing low temperatures such as would induce extreme dormancy, and without any frost or snow fall. Every variety has also a specific requirement for total heat during the growing season for maturing its fruits. In general, high temperatures are believed to promote high sugar content in fruits, while low temperatures may cause delayed blossoming or may even destroy the blossom or fruit crops. Excessive rise of temperature may cause injury to young leaf, flower and fruit. Under clear weather and high prevailing temperatures, insect pests find favourable conditions to develop and to cause damage to fruit trees, while in insect-pollinated fruits, low prevailing temperatures may inhibit the insect activity and thereby adversely influence fruit set.

B. *Atmospheric humidity* :—Several South Indian fruits like the mangosteen, mandarin etc., can only thrive where high atmospheric humidity and high temperatures prevail : they are a failure in warm and arid zones as well as in cooler areas. With most other fruits, however, high atmospheric humidity has an unfavourable effect on appearance, colour and keeping quality of fruits. High humid conditions also foster fungus and bacterial growth, which may be harmful to fruit trees. Live plant parasites, lichens and sooty mould are especially common under such conditions. There are some regions where atmospheric humidity is high only for a short period as during the south-west monsoon in the West Coast. This feature does not permit the successful production of mangosteens in the West Coast, while it is no bar for many other fruits like the pineapple, sapota, jack etc. These show that fruits differ greatly between themselves not only in their reaction to the degree of atmospheric humidity in any one period, but also to the range of humidity in a year.

C. *Rainfall* :—The amounts of annual precipitation as well as the distribution of rainfall have important effects on the fruit-growing industry. Heavy rains occurring in short periods are generally unfavourable to fruits, since they may lead to water-logging and may also adversely affect the standing crops of blossoms and fruits. In the case of some fruits, rains at full blooming time may lead to washing away of pollen and inhibition of the fertilization. In the West Coast where heavy rains commence in about June, it becomes necessary to harvest mango fruits early, since the standing crops are liable to be shed or affected by fungal or bacterial diseases which thrive during the monsoon period. Low rainfall too is to be deemed a disadvantage, since it would necessitate a higher cost on the maintenance of irrigated groves. In sites or zones subject to precarious rainfall, irrigated orchards should only be established, therefore, after the water supply is assured in required quantities at all periods of the year. Heavy rains have been known to hinder pollination by insects, injure the pollen, and prevent the pollen germination by diluting excessively the stigmatic secretion.

D. *Wind* :—High winds or cyclones are always a source of danger to fruit trees and crops, and may prevent pollination by bees. Heavy loss of fruits and flowers by shedding or sometimes complete dislodging of trees or breakage of limbs form the mechanical damages resulting from strong movement of air. Fortunately for South India the desiccating winds, dust storms and cold winds which are common in the North, are unknown ; but yet even the less harmful winds of some velocity do often cause some interference with the pollination in fruits. All fruits resent cyclonic winds. The producers avail the knowledge of the greater resistance enjoyed by some varieties in establishing their orchards. Planting of the dwarf Mauritius or Cavendish banana

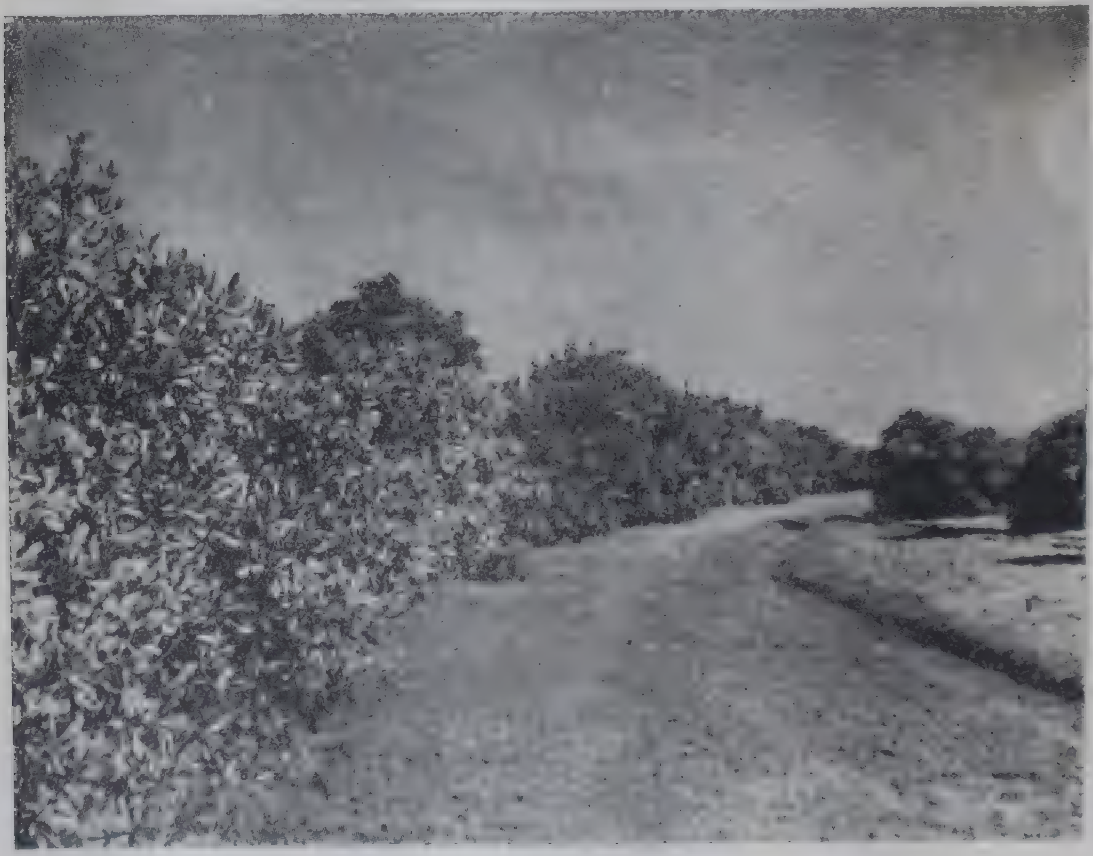


Fig. 1. Cashewnut planted as a wind-break

in the cyclone infested areas in preference to the taller varieties like Poovan and Monthan, and establishment of thick wind-break belts are the devices to counter the adverse influences of high winds.

E. *Light* :—In the tropical regions light is a factor of little significance, unlike in the temperate zones. For securing good colour, which is associated with the fruits exposed to light, wider spacing, thinning of the top, or training the trees to open—centre are usually practised. In zones where summer temperatures are high, damage due to exposure of fruit and tree stems to sunlight has to be expected. Often, the young fruit exposed to intense sun light gets scortched, resulting in malformed and misshapen fruits. With mangosteens, exposed fruits in zones of low relative humidity exude gum and thus become gamboged. The tender stems and branches of trees with insufficient canopy may also become sun-burnt.

F. *Hail* :—Hail, like the frost, is of extremely rare occurrence in South India, unlike in the North, and causes little or no damage to fruits. The occasional occurrence of hail, however, has been found to cause some flower and fruit shedding, and some damage to very young fruits on the hills.

Variations within a zone :—Even in a given area, all the sites may not necessarily enjoy identical climatic features. The slope, exposure, elevation, extent of rainfall and distribution and the type and nature of surroundings may severally and collectively bring about large local variations, which render it necessary to make a careful selection of the orchard site. This accounts partly for the varying performances of a given variety within a zone or locality, and for the variations in particular in the date of fruit maturity. In the Kodur area, it is known for instance, that the Sathgudi oranges can be retained on the trees till about February in some orchards, while a few miles away the fruits have to be picked by December.

SOUTH INDIAN FRUIT ZONES

It is common to broadly classify fruits into certain groups, based primarily on their temperature requirements. Thus, under the temperate zone are placed all fruits which have a high resistance to severe winter conditions and have a definite period of dormancy, such as the apple and pear. The second zone is designated as the warm temperate zone, where such fruits as Japanese plum and peach, with a moderately high resistance to winter cold and which also require a dormancy period are placed. The third zone is for sub-tropical fruits, which include both deciduous and evergreens with slight to moderate resistance to winter cold and with a high requirement for heat. These include such diverse fruits as the date, mandarins, guava, avocado, persimmon, fig, pomegranate, *jujube,* orange etc. The last group is of tropical fruits, which includes only evergreens such as mango, pineapple, sapota, mangosteen, cashew, papaya etc.

It is clear that the above grouping is neither natural nor satisfactory. Firstly, each of these four groups includes several fruits with distinctly different climatic requirements. For instance, it will be incorrect to presume that the date thrives best and invariably where mandarins do, or that the mango and mangosteen can be grown very successfully on the same site. As a matter of fact, the date and guava are found to thrive in South India in the hot and arid plains, where avocado and mandarins will not prosper. Further, most of these have varieties which differ from each other in respect of climatic requirements. It is, therefore, inferred that the more satisfactory method of classifying the fruits is on the basis of their present commercial importance in each of the various zones of South India. It is on this basis that the fruits have been grouped in Part II of this book.

South India is blessed with a very richly diverse climate, which favours the production of almost every fruit. On the basis of the available knowledge of the performance of leading commercial fruits, the following fruit zones may be delineated in a very rough way.

1. *Hill Fruit Zone* :—This is represented by the Nilgiris and Palnis above the altitude of about 5,000 feet from the mean sea level. Hardy varieties of apples, pears, strawberry, Japanese plums, some varieties of peaches, persimmons, cherimoyer, tree tomato and passion fruit thrive in this zone.

2. *Warm Humid Zone on the lower hill slopes*:—This is typified by parts of Wynad, slopes of the Nilgiris, Shevroys and Palnis, parts of Coorg and Mysore between an altitude of 2,000 to 5,000 feet, Courtallam, parts of the Anamalais etc. Mandarins, mangosteen, papaya, Sirumalai banana, jack, pineapples, litchi, breadfruit, carambola, rose and star apples, avocado, langsat and durian are found to thrive here.

3. *High Rainfall and Warm Zone* :—Malabar, South Kanara and greater parts of Cochin, Travancore, and parts of Mysore between the sea level and 2,000 feet above it fall under this zone. Mangoes of early varieties, bananas including the Nendran group, jack, breadfruit, pineapple, cashew, lemons, pummeloes, rose and star apples and sapota are the chief commercial fruits of this zone.

4. *Dry Districts of low rainfall* :—The rest of South India is brought under this zone, constituting the largest cultivable area. Mango, banana, sapota, sweet orange, lime, lemons, grapefruit, guava, fig, pomegranate, grapes of some varieties, *jujube*, date, cashew, jack, and annonaceous fruits except the cherimoyer, are the major fruits of this zone.

The above divisions, as has been already mentioned, are undependable, since there are variations within each zone and between varieties. These facts render it impossible to adopt any rough and ready method for determining the suitability of a fruit to a given locality. For instance, although parts of the Nilgiris on 5,000 feet elevation and above are brought under one zone, there are several varieties which thrive well on the higher elevations than on the lower within the same zone. Certain hardy varieties of apples are also known to be under cultivation near Bangalore, which is below the lower limit of the hill fruit zone. Similarly, in the second zone there are large differences between such heavy rainfall tracts as Wynad and Courtallam. These instances would suffice to show that the suitability of a fruit to a given site is conditioned by the cumulative effects of a host of factors ; and a rough delineation of a region will therefore afford no correct guidance. It is nevertheless of some help to have the major zones delineated for emphasizing the chief climatic variations within South India and for indicating the commercial importance of the main fruits in each of these major divisions. It is for instance, a vain venture to attempt pineapple, banana or mango culture on the hill fruit zone, as it would be to raise apples, pears and strawberries on the dry or humid districts of the South Indian plains. Subject to these, there is no better way of selecting a variety for a given site than on the basis of the observations of the performance of that variety in the neighbourhood. Local experience, or preferably actual varietal tests, are necessary pre-requisites to intelligent commercial fruit culture ; and this explains the justification for variety collection areas or testing grounds in each zone.

SOILS IN RELATION TO FRUIT PRODUCTION

Between two sites enjoying similar climatic features, the influence of soil is often found to be the deciding factor between success and failure in fruit farming. It is not universally recognised, but it is nonetheless true that a soil considered good for seasonal agricultural crops need not necessarily prove suitable for fruit. The latter with its deeper foraging capacity of its roots and its perennial nature, requires for its success not merely a good surface soil but also an equally good sub-strata. The physical condition of the soil in orchards is also often of greater importance for success than the chemical composition, unlike in agricultural farming.

Requisites :—Porosity, aeration and depth are the principal features which are taken into account in judging the physical condition of the soil in relation to fruit-growing. Experience has proved that the ideal soils in South India for tree fruits are those that are at least six feet deep, uniformly textured up to that depth, possess perfect drainage, and have a water table about six feet below in any period of the year. Most tree fruits send their feeding roots up to six feet depth, and some even beyond—up to about eight feet. Variation in texture in this feeding zone leads to marked differences in soil moisture content, nutrient supply and aeration ; and consequently to un-uniform root distribution and sometimes to serious injury to a part of the root system. It is common for instance, to find in soils with sandy layers on the surface and clay layers below, the tree roots devoid of moisture in the upper layers while the lower layers may be excessively saturated to an extent as to cause root injury. Even so, in soils where stiff layers are superimposed over sandy layers below, there is a considerable and rapid loss of moisture and nutrients through the lower layers to areas beyond the reach of the roots. Variations in soil texture also bring about uneven drainage conditions. It is not sufficiently realised what a great deal of harm is caused to fruit trees by defective drainage and inadequate soil aeration. Hundreds of Vadlapudi orange trees in the Circars have met with a premature end, and numerous sweet orange groves in Sirvel taluk of Kurnool district have been found to have an extremely short life, because of the presence of high water tables. A high water table—permanent or fluctuating—rising within about six feet of the surface even for a short period should be ruled out as unsafe for fruits. There are instances where scores of bearing jack fruit groves have been wiped out in South India, consequent to a sudden rise in the water table. High water table not only inhibits aeration, and in extreme cases leads also to the rotting of the roots by prolonged submergence, but it may also bring in its train a host of diseases which may persist in their disastrous after effects long after the water table has receded to a danger-free sub-strata.

Texture :—Between soils of different texture fruits generally prefer a moderately open soil, although there is a great deal of variation between the kinds and varieties of fruits in respect of the degree of tolerance or preference to any given texture. Very light and almost pure sandy coastal areas have been used to raise some fruits commercially, in some cases with marked success. But in these cases as well as in soils of the other extreme, viz., on stiff clay, the success of the grower is more a tribute to his intelligent care in modifying the soil defects than to the excellence of the soil. Rapid moisture penetration, low moisture storage capacity, and marked tendency to lose much of the moisture and plant food by leaching, are the characteristics of soils of open texture such as the gravelly, sandy or sandy loam soils. On the other hand, heavy soils like the clay and clay loams are characterised by slow moisture penetration, poor soil aeration, high moisture and plant food storage capacity. These soils are also difficult to work and more expensive to be provided with drainage facilities. The medium-textured loams are therefore to be generally preferred for fruits, provided other conditions such as absence of a high water table etc., are fulfilled. Examination of soil profile in six feet deep pits is considered essential before one invests on an orchard. Such pits should be dug in several sections of the land so as to examine the soil in all the heterogeneous parts of the area. The variation in soil texture is sometimes so great within a few feet that it is risky to adjudge the suitability of a site from one pit dug out at random on the site.

It has to be recognised that it is relatively easy to modify the chemical composition of the soil rather than its physical condition, and the surface soil than the sub-soil. The latter have perforce to be taken as they exist. This therefore invests the subject of physical condition of the soil and sub-soil with considerable importance.

Soil temperature :—Soil temperature requirements of different fruits vary to an extent, and the optimum temperature range necessary for root activity of each fruit is useful, if known. Unfortunately, sufficient data on this subject is unavailable under South Indian conditions. Soil temperature is affected primarily by aeration and drainage of the soil as well as by the prevailing atmospheric temperature ; well-drained, light to medium soils attaining the warmth earlier than ill-drained soils after the winter and thereby assisting in an earlier maturation of fruit. In seasons of low temperature or excessive and prolonged rains, the root activity therefore tends to start relatively late, and this fact explains the late blossoming and fruit set, as it happened with mango and citrus in 1947 in South India.

Despite the foregoing facts, there are some differences between species and varieties in regard to their soil preferences. Some of the peculiarities of each of the major fruits of South India are discussed in Part II.

Shallow soils :—Many orchards in South India have come to grief because they were raised on shallow soils. It has to be remembered that a tree with a deeper root system, even though growing in a poor soil, is in a better position than the one in a richer but shallow soil. Soils with hard and compact layers of kunker, rock, broken stones and gravel with little or no admixture of soil, are common in many parts of South India. In many instances such adverse sub-soil layers are superimposed with good soil, which is found excellent for general agricultural farming. The premature death of mandarins in several plantations at Yercaud has been found to be largely due to the existence of rocky sub-strata close to the surface. Examination of roots of trees under such soil conditions reveal the restriction of all roots to the few inches of surface soil, with all the supporting root frame-work spread out almost horizontally at right angles to the tree trunks and running parallel to the surface soil. Such trees show distress soon after bearing a heavy load of fruits, and are also liable to serious damage by high winds. On rich soils as those in Coimbatore district as well as on the lateritic hill slopes of the West Coast, poor growth and unthrifty appearance of many trees have been found directly due to the occurrence of compact and impenetrable kunker layers or hard stone or gravel respectively, close to the surface. The existence of such adverse sub-strata may be extensive or localised, and these cannot be detected by a superficial judgment of the surface soil.

CHEMICAL COMPOSITION

To choose a saline or alkaline soil for fruit is a disastrous error, which has caused immense loss to growers in the past. Most fruit plants prefer a nearly neutral soil reaction, although some may tolerate or even prefer a slightly acid medium, while others may demand slightly alkaline medium. A pH range between 6 and 8 may be generally deemed to be safe for most commercial fruits in South India. In the alkaline soils, concentrations of sodium salts above 0·1 per cent. is considered dangerous to several fruits. Many physiological disorders of fruits have now been traced to the high alkalinity of the soil, and some of these are dealt with under *Citrus* in Part II. In acid soils, it has also been shown by some workers that certain micro-organisms flourish to such an extent as to act pathologically, while the biological activity favourable for the growth of the trees may be retarded. Alkaline soils cause nutritional derangements in plants. They may also corrode the roots, break down or deflocculate the soil granules, rendering it difficult to work the soil, and for water penetration. Many trees grown in alkaline soils exhibit chlorotic leaves with burnt leaf tips and edges. Excessive defoliation may also occur and the new leaves may be undersized. In severe cases premature tree deaths result. Alkali injury is more severe in dry soils, since the reduction in soil moisture increases the concentration of the soil solution. Leaching of the salts out of the soil by heavy and frequent applications of water has therefore been suggested as a remedy. Drainage and green manuring have also been advocated. In certain sites, however, especially in arid regions, the rising water table brings near the surface the salts that would otherwise have been retained below. In such cases over-irrigation should be avoided, and the irrigation should be done at long intervals. Since it is expensive, if not difficult, to bring the base status of the acid soils to the desirable level, because of the fact that the corrective applications of fertilisers is done only to the soil surface, and the fact that the materials move at a slow rate, the natural soil handicaps cannot be got over by an easy and cheap method. The correction of excessive alkalinity is even more difficult and expensive. For ensuring a desirable performance of trees, therefore, it is best to have the soil as well as the irrigation water analysed chemically at the very outset and obtain the opinion of a competent chemist.

Soils with high concentrations of soluble salts are no doubt easily detected, since they exhibit incrustations or deposits on the surface layer and are sometimes barren or are occupied by only salt-resistant flora. It is those soils which do not show such clear symptoms that often cause disappointment, and in which chemical analysis is the only means open to judge their suitability.

Generally speaking, however, fruit trees can flourish in a soil considered not sufficiently fertile for certain agricultural crops, because of their deeper root penetrations and the consequent ability to draw the food from a larger area, beyond the reach of seasonal crops. This statement should not, however, be taken as without exceptions; for it is now proved that for achieving success with some deep rooting commercial fruits of South India as the grape and citrus and shallow feeding fruits like the banana, much heavier availability of plant foods is required than given to most seasonal crops. In regard to the important food elements, the deficiency of nitrogen in a soil is not considered as serious, since this element is commonly applied during the annual or seasonal applications of manures and fertilizers. Such is not the case in respect of phosphorous and potassium. Because of their surface fixation when applied to soils, they cannot always be easily replenished. A soil well supplied by these two elements is therefore an asset ; and fortunately most South Indian soils are not found wanting in these.

Colour :—Soil colour has often been given in South India an importance much beyond the justifiable limits. This is because of the fact that in certain areas the fertile soils happen to be of a particular colour. Whether the soil is red, dark or chocolate, it is of little or no significance, so long as it satisfies the other and more important conditions discussed above. A red soil of low depth and poor drainage does not become suitable merely because it has the particular colour, any more than a dark soil is defective even though it has the desired depth, texture and chemical composition.

OTHER FACTORS IN SITE SELECTION

Transport facilities by rail and road and nearness to the market are important factors which determine the profits from fruit-growing. Fruit being a perishable commodity, is liable to considerable damage while it is transported over long distances. This and the higher cost on long distance transport may eat away considerable slices of the profits. In the production of most fruits, however, irrigation accounts for the largest item of cost. The grower should determine the quantity of water available in the driest season, since it is at that period the water is most urgently and plentifully required. Starting orchards without ensuring adequate quantity of water has resulted in the total or partial wiping out of several trees or orchards in periods of acute drought, causing grievous loss to the owners. The quality of water should also be got tested by a chemist whenever there is any doubt. In some places bad water may gradually add toxicity to the soil rendering tree life precarious. The cost of obtaining water from the existing sources is also an important consideration which has to be looked into, in the interest of economic orchard management.

In some parts cyclonic weather or high winds often cause considerable loss to fruit crops. The force of wind is stronger in some aspects, as e.g., in the western and southern aspects in the West Coast. A site well-sheltered and affording protection from strong winds by high mounds or hills or thick wooded land on the windward side, should therefore be chosen. Establishment of strong live wind-breaks should also be considered essential in such regions, and these should be established in advance of the fruit tree plantings.

A site on a steep slope is subject to erosion and is difficult to cultivate, and should therefore be avoided. Even on gentle slopes the topography should be such as to involve minimum of initial outlay on terracing and on the formation of irrigation channels. Excessively undulating sites will also mean higher cost on levelling. In sloping shallow soils terracing is not always possible, as it may expose the underlain rocks or defective sub-soil layers. If slopes cannot be avoided as on the higher altitudes, it will be desirable to select a site least subject to soil washing, or one where protection against soil washing can be easily undertaken.

The price of the land, the cost of clearing the site and of preparing drains, are other items that have to be considered. It will also be wise to see that the site fancied is not near any badly diseased fruit plantation, although it will be safe to select a site close to established and successful, but healthy groves, so that co-operative marketing of the produce can be undertaken. Fruit-growing being a whole-time occupation extending to generations, a regular supply of labour close to the selected sites is also an advantage. The availability of certain social and other amenities to the grower and his family are by no means the least important of the points that one has to reckon with in the final choice of the site.

Persons who have ignored one or more of the above factors often realise their mistakes at a stage when there is little or no remedy. A long range investment, which is fruit-growing, cannot be a success by hurried treatment or by speculative methods. The greater the care one takes in selecting the site, the more assured is the future success of the orchard. The reader therefore will be well advised to consult experienced fruit workers in this basic and all-important task of site selection.

SOIL EROSION

It has been estimated that in the United States of America alone about 500,000 acres of good land goes to ruin every year due to uncontrolled erosion (Bennett). Being unstable, the soil moves from place to place when left unprotected. Such a loss is of serious consequence in cultivated orchards and has often been the cause of ruin. Soil conservation is done by several methods, such as terracing, contouring, bunding, addition of organic matter, grassing or cover cropping, raising of wind-breaks, improving of drainage and orchard cultural practices. Terracing is specially useful on rolling ground or hill slopes, where the aim is to catch rainfall and allow much of it to soak into the soil. Orchard soil culture along the contour furrows also helps to hold the rainfall. Ridging or bunding the orchard land on the contour also intercepts rainfall through the low soil barriers, especially if assisted by diversion channels built across slopes to divert damaging or wasteful run off. Planting of strips of grass on the bunds or edges of terraces or fields, or cover cropping the orchards or on the contour in strips, also helps not only to hold water but also to catch the soil by straining it off from the run off. Mulching the orchard with crop residues etc., is another device to check the erosion in orchards. Artificial drains are necessary in orchards for promoting better growth and performance of fruit and also for rendering the site free of the excess of water by controlled distribution of the run off. In some areas protection of the river, stream, or channel and drain banks and sides becomes essential to reduce the loss of soil. Planting of eroded or erodable land with trees, shrubs, grasses etc., is an important step, as also the raising of wind-breaks which serve to deflect the wind currents, reduce wind erosion and conserve rainfall. Defective layout of orchards is often a potent cause of soil erosion, while excessive and untimely orchard soil culture aggravates the loss. Efficient soil conservation involves, therefore, a great deal of care in planning the orchard and in its maintenance methods, to all of which the grower has to pay sufficient attention if his venture is to be of full value. Among the commercial fruits of South India mango is an example of rain-fed orchards on the plains, and which is given little soil culture. Dividing such groves into sections, each with level ground and with turfed bunds to demarcate each other or around each tree and maintaining a cover crop every year in the monsoon season, are some of the means to control soil erosion. Citrus groves on the other hand, are examples of orchards in which cultivation is often done to an excess with little or no protection against soil washing or damage by flood water from near-by streams or rivers. Protective works against flood damage, limiting the soil culture to non-rainy periods and raising of an inter or green manure crop by rotation during the rains in the pre-bearing age, are essential. Bunding of the citrus groves is often done to form irrigation basins and this provides also an effective insurance against soil washing. With bananas bunds and drains at close intervals are normally essential, while on the slopes of hills the planting of trees on terraces or in contours, with suitable bunds on the edges of terraces, diversion channels, as well as cover crops and mulches are necessary as soil erosion control operations.

Drains :—These are either open or covered. The former may lead to soil washing, if not laid down on fairly level ground with catch pits at suitable intervals. Among the latter, tiled drains lined with porous material or with earthen pipes with holes on the sides, have been tried in a few places, but have been found expensive. Where boulders are available easily and cheaply, these serve the best material for packing the drains. The boulders or tiles are packed about 12 inches below the surface, and are covered over with soil, so as to permit the tillage implements to work in the orchard without any impediment. All such drains should be straight to permit easy flow of surplus water, and they should slope gently to a natural outlet. When any localised ill-drained spots are met with in an orchard, a successful method tried at Kodur is to dig out drains on either side of the spot with a steep slope in a manner that the two drains converge to meet together at a convenient spot, where a deep pit is dug to contain the drained water. Both the drains and the pit are then packed with boulders, with 12 inches of soil cover on the top. Such drains dug on the sides of individual trees standing in badly ill-drained spots, have been helpful in keeping the trees alive and in a fairly satisfactory performing stage, although prior to the formation of drains repeated replanting on the same spots was of no avail.

List of References

1. Bennett, H. H.—Our American Land, Misc. Publication, U. S. Dept. Agri., 1947.
2. Chapman, H. D. and W. P. Kelly.—The Citrus Industry, Vol. 1, University of California Press, 1946.
3. Chandler, W. H.—Fruit Growing, Houghton Mifflin Company, New York, 1925.
4. Gardner, V. R., F. C. Bradford and H. D. Hooker Jr.—The Fundamentals of Fruit Production, McGraw Hill Book Company, New York, 1922.
5. Naik, K. C.—Survey of the Ceded Districts for determining the Possibilities for extension of Fruit-growing Industry, Published by the Madras Government, 1942.
6. ,, Climate and Its Influences on Fruit Production, *Mezhichelvam* (In Tamil), Madras, September, 1946.
7. ,, Soils in Relation to Fruit Growing, *Mezhichelvam* (In Tamil), Madras, October, 1946.
8. Webber, H. J.—Plant Characteristics and Climatology, The Citrus Industry, Vol. 1, University of California Press, 1946.

CHAPTER III

FRUIT NURSERY PRACTICES

Importance of nursery trade :—The fruit nurseryman is the natural mentor and guide to the fruit producing public. It is to him that the public sometimes turn for advice on what varieties and kinds to plant, when to plant, how to plant and tend the trees, etc. This logical role that the nurseryman has to play is taken note of seriously by only a few in South India. In several lands the advisory function of fruit nursery establishments is given such a high prominence that, some firms have established information bureaus and even research organisations of their own. Some have even evolved new varieties or strains by breeding. No nurseryman can fulfil his legitimate function if he fails to keep himself abreast with the increasingly available scientific and practical information. It is only thus that he can hope to adjust his own trade and methods, and to advise the public to do likewise, to suit the ever-changing conditions in the fruit growing world.

The fruit plant is the foundation of orchard structure and is the primary factor which determines the success or failure. When one purchases a fruit plant he expects to reap fruits from it, sometimes after five to ten years, and for a period that may extend to the succeeding generations. Thus, orcharding is a long-term profession, and one cannot afford to take a risk in choosing the plants. A nurseryman who dishonestly passes off a plant under a wrong name, or sells spurious plants, or attempts to clear his stock by inducing the purchaser to take plants unsuited to his site, causes a great disservice to the country and incidentally to his own future interests. The resultant loss is recurring for many years, and this feature is common in all parts of the country. The crime is all the greater, because it cannot be detected easily for several years, and is committed with full knowledge of the fact that at present there is no law to get the offender booked. Nurseries can therefore make or mar the fruit industry of a region. In a country where the public in general are horticulturally ignorant, the importance of the role that the nurserymen have to play is immeasurably great. It behoves both the fruit grower and the nurseryman to be alive to their respective responsibilities and interests, and that of the region as a whole, in the matter of purchasing and sale of fruit plants.

Layout :—A commerical nursery can be roughly divided into different sections, viz., (1) seed beds, (2) nursery beds, (3) pot yard, (4) packing yard, (5) store, working shed and office.

The seed beds occupy a small space and are to be confined to an area where exposure is available. The beds are raised from the surface to provide effective drainage. Under shade many seeds fail to germinate quickly, and after germination the seedlings are more liable to suffer from damping off disease than in the open. The soil in the seed bed area should be open-textured; and heaps of river sand of varied degree of fineness should be ready at hand for mixing with the soil or covering the seeds with a layer of it after sowing. Well-rotted cattle manure or compost in a fairly pulverised condition is the popular ingredient mixed with the seed bed soil, and this too should be available on the spot for frequent use. Since frequent and daily watering mainly by hand is essential for the seed beds, they should be located close to a water source.

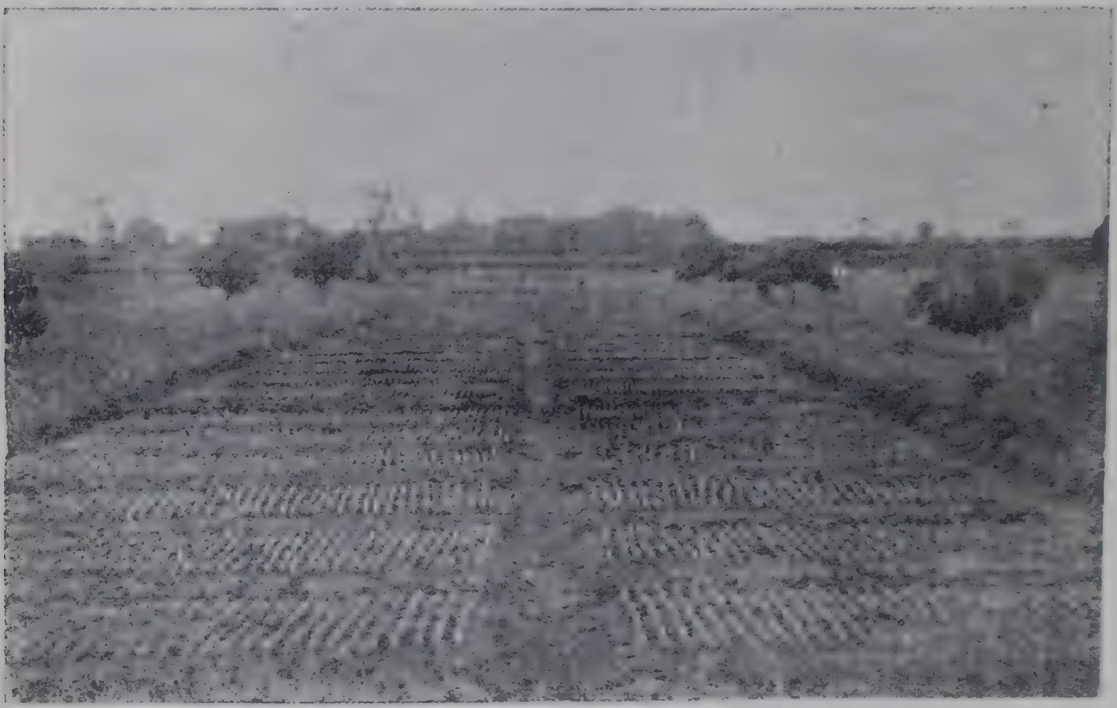


Fig. 2. A general view of seed beds at the Fruit Research Station, Kodur.

The nursery beds are more extensive than the seed beds, but should also be well exposed and close to an irrigation source, even though the irrigation is to be done by the flow method. Separate sections of the nursery are usually allotted to plants of each fruit variety or kind, with another for rooting of cuttings as well as for layering in beds, and a third for sowing seeds like those of the mango. Open texture and perfect drainage are essential for the soil devoted to nursery beds. Owing to the fact that plants in the nursery are retained for long periods, the soil gets exhausted quickly. To counteract this, rotation of crops and occasional green manuring are practised. A workable procedure may be to divide the nursery bed area into several sub-divisions, as for example (*a*) for mango seed beds, (*b*) for rooting of cuttings, (*c*) for citrus plants, (*d*) for other fruit plants, and (*e*) for green manuring. In the following year rooting of cuttings may be done in (*a*) sub-section, citrus plants be restricted to (*b*), other fruit plants to (*c*), green manuring to (*d*), and mango seed sowing to (*e*). This system of rotation of crops and green manuring can be modified to suit the peculiarities of each nursery area, with the main object of maintaining soil fertility as best as one possibly can. Besides, frequent or annual application of manure to the nursery area has to be arranged for. The layout of the nursery beds should be such as to provide for easy access to all beds as far as possible through roads or paths, and without necessitating the work men to walk over bunds and water channels.

The pot yard is a distinct section where shade is available for tender plants and exposure to the hardier ones. Water supply is as important to this section as for seed beds, since hand watering of some plants in pots may be essential at frequent intervals. Trenches are to be provided for keeping potted plants closely packed and to be watered once in four to seven days, by letting in flow water to the trench to a depth as to reach just an inch above the collar of the plants, as will be explained in Part II, Chapter I. This leads to economy in irrigation, as against the widespread practice of watering the pots by hand every day. Compost, leaf mould, sand, crock, pot-mixture heaps and storage place for pots of various sizes should have their allotted spaces close by, preferably under the shelter of a roof. A small water storage tank will be useful. A working shed to enable the potting of plants even during rains or inclement weather, should also be here, preferably attached to the sheltered storage space for pot-mixture heaps.

The pot-mixtures used in South India are by no means uniform. Whatever the mixtures be, it is the widespread practice to have one hole for drainage in each pot at the bottom, or two holes on the sides of the pot at the lowest edge. Such holes are provided only in earthen or bamboo pots, but not in wicker or bamboo chip baskets or in hill grass or coconut husk or coir containers. Over the hole in the former classes of pots, crocks or broken brick pieces are thrown in to about an inch depth in such a manner as not to close the hole completely. To ensure this, a curved piece of a broken pot is placed first, usually with its convex surface pointing upwards or away from the hole, after which the crocks or broken pot pieces are thrown over. Over these are placed a one or two-inch layer of fine sand. The pot-mixture is then thrown in. This may consist of one-half to two parts of good loamy soil, three of leaf mould and about six parts of sand, if the pots are to be used for sowing seeds or planting cuttings. The pot-mixture for other plants such as mango seedlings or layers of guavas, usually comprises of two to three parts of loamy soil, two to three parts of well rotted manure or compost and one part of fine river sand. These various mixtures are kept ready made, by heaping each component part in layers one over the other in the required proportions, so that the required quantity can be removed at any time and used after mixing well all the ingredients.

The packing yard is meant for packing the plants prior to their sale or despatch to out-stations. This can well be combined with the working shed. Enough space should be available here for sorting out the plants and packing the plants by a number of workers simultaneously. Packing material such as baskets, crates,

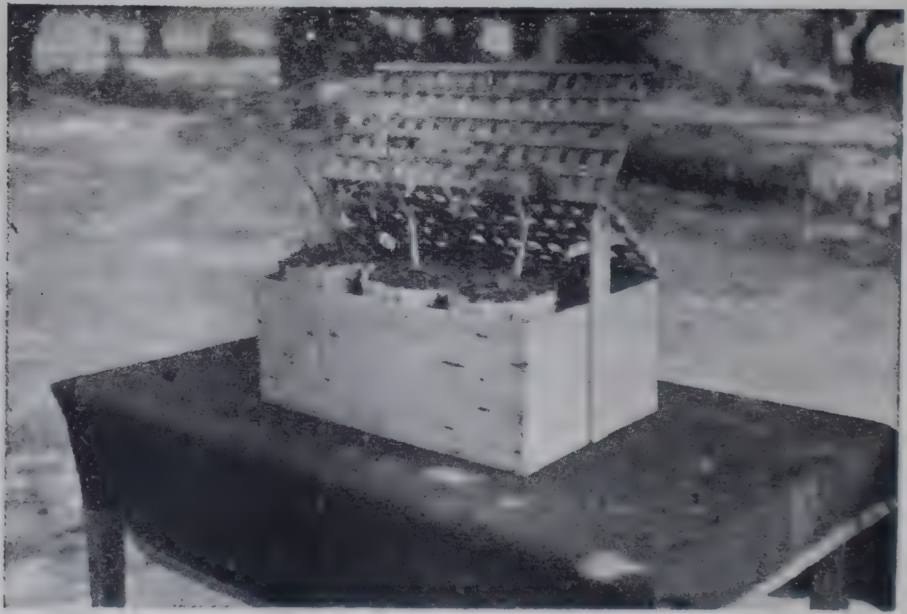


Fig. 3. Plants packed for air transport. View of the contents.

labels, nails, rope etc., may be stored here in a room or kept in the adjoining store combined with the office.

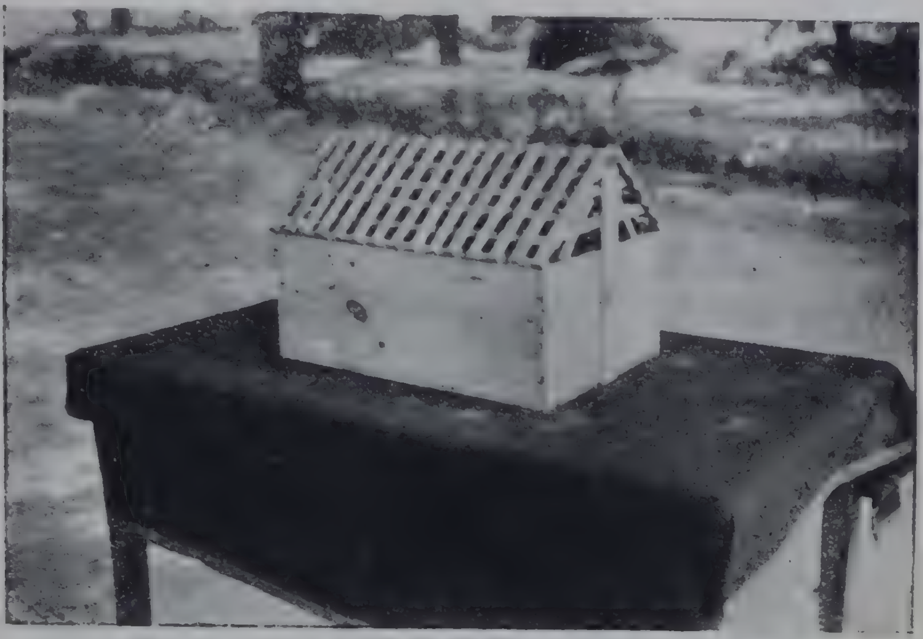


Fig. 4. Plants packed for air transport. View of the closed package.

The office is to be both a place of work for the staff of the nursery as well as a room for interviewing the purchasers. The furnishing and equipping of this room attractively with an eye on advertisement and education are worth keeping in view.

No fruit nursery establishment can be complete without an orchard attached to it, containing collections of reputed varieties and kinds of fruits, to provide the necessary dependable source of scion and rootstock materials free of any elaborate transportation cost, and for facility in performing the inarching, layering, gootee and root-suckering operations. A well-stocked orchard contiguous to the nursery will also inspire confidence among the purchasers, besides being economical in the working of the nursery. Any nurseryman who depends on others for the supply of scion and rootstock material has hardly the justification to sell plants with that confidence to the purchaser, as another who is in a position to adduce proof that his scion and rootstock parents are all of tested merit.

Culture :—Hand forks are largely used in seed beds, but sometimes weeding is done on these beds by only pulling off the weeds by hand. As the space between rows is narrow and as seeds do not all germinate at one time, more elaborate culture is not possible. Watering is done by hand in cans fitted with a 'rose', but later water can be let in between the beds by flow. The size of nursery beds

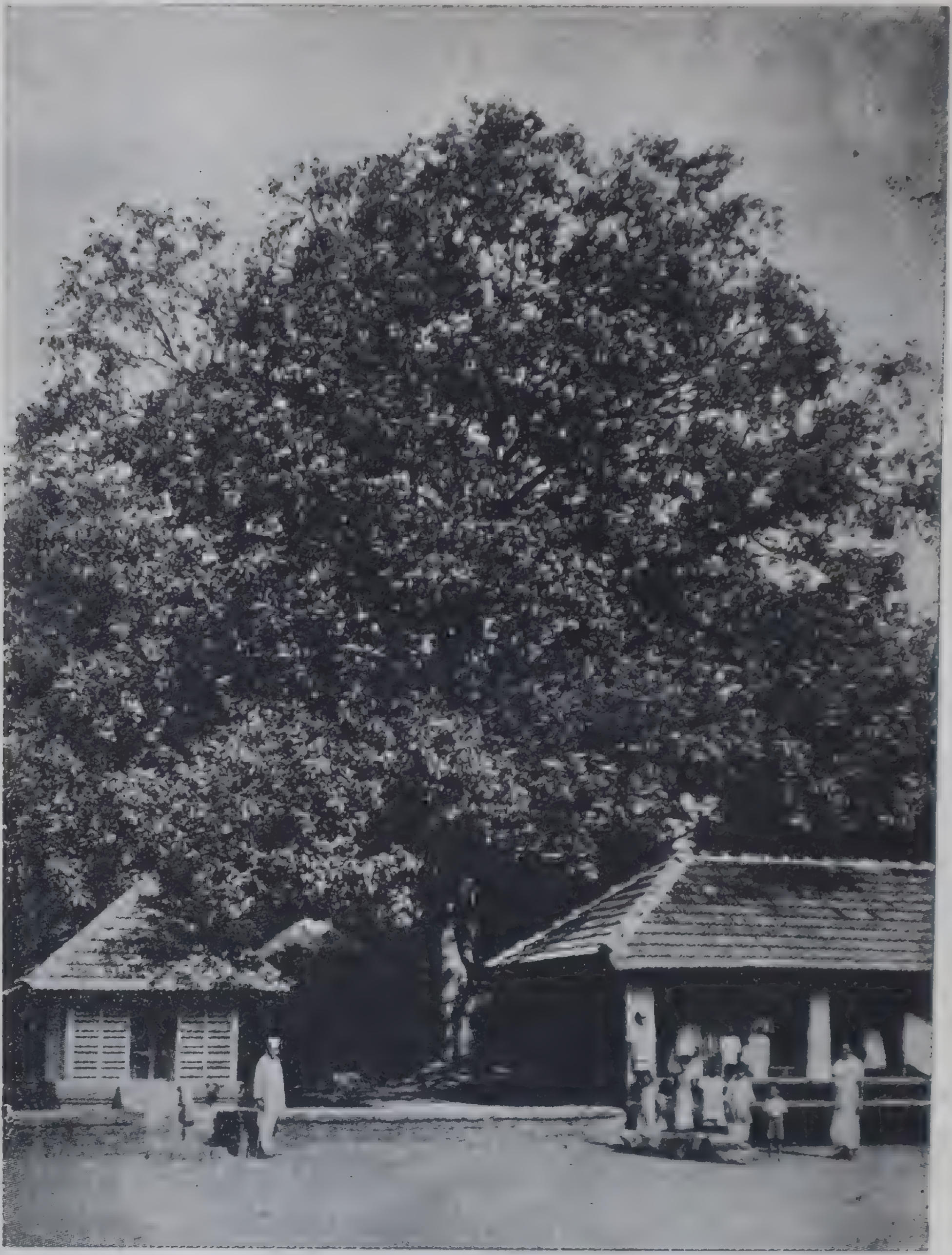


Fig. 5. Original parent of Kadri mango, a reputed variety of the west coast.

varies according to the number of plants to be raised, but they are generally not more than 20 feet wide and 50 feet long. Water is run through furrows between alternate rows of beds. While the preparatory cultivation is done by ploughs, the inter-cultivation in the beds after the seedlings are transplanted and are clearly visible in the rows, is mostly by Planet Junior Hand Hoe or by *mummoti* or other small hand tools like the *dokudupara*. Deep cultivation is not advisable as it will lead to root injury and may force the roots to penetrate very deep, making the subsequent lifting of plants difficult and possibly endangering their life in transit. Irrigation should be frequent but not excessive. In the former case the object is to foster regular growth and prevent deep rooting. If excessive, the growth will be succulent and soft. Just a few days before budding or side grafting etc., is to be commenced, one watering should be given to make sap flow free and active and to induce the bark to peel off readily. Manuring may be done to force the growth if necessary, through the application of quickly available nitrogenous fertilizers like ammonium sulphate. But it is a better plan to apply organic manures like farm yard manures or oil cakes every year after the beds are cleared of a batch of plants and while the land is prepared for the next batch. From this stage to that of planting there will be an interval when the manures and green manure crop stubbles will have been fully decomposed and incorporated, and the soil will have become mellow enough for fresh transplanting.

PROPAGATION METHODS.

SEXUAL METHODS.

In most horticultural plants the progenies from seed are very variable. We cannot for instance, raise seedlings from a Neelum mango to resemble the parent in any material respect. The seedling progenies are frequently inferior to the parent and worthless as commercial sorts. For commercial orchards it is essential to have all the trees possessing uniform quality, growth features and yielding capacities. The markets demand also fruits of known or standardised quality, which cannot be secured from seed. In brief the defects of seed propagation generally are :—

1. Standardised fruit quality, so essential for economic success, is rendered impossible.

2. The growers are never sure what crop yield and quality their trees will produce; and commercial fruit-growing will, therefore, become a risky and uncertain venture.

3. Choice trees which arise by chance in Nature cannot be perpetuated, and therefore, are lost altogether.

4. If a soil is unsuitable for one variety, or the variety is susceptible to a disease, there is no possibility of growing the same by the use of the modifying influences of rootstocks as in the case of vegetatively propagated plants.

Sexual propagation has, however, certain uses. Ordinarily, the seedlings are more hardy, more adaptable, deeper rooted, longer lived and better yielders. These advantages are utilised in horticulture by using seedlings as rootstocks for budding or grafting to known varieties. In breeding work also seed propagation has to be employed. Occasionally, chance seedlings arise in Nature and some of these chance seedlings are of superior merit. Most of our present superior cultivated mangoes have originated in this way, and some of the seed parents like those of Chinnasuvarnarekha of the Circars, Mundappa of the West Coast and Padiri of Tamil Nad are believed to be alive even to this day. At Kodur some chance seedlings of superior merit of mango have also been located recently and are being multiplied by vegetative means.

Some fruits like the Olour mango, *Eugenias,* mangosteen and most *Citrus* are capable of producing more than one seedling per seed due to a phenomenon called polyembryony. This is because of the presence of more than one embryo in the seed. Polyembryony may arise in various ways. It may largely be due to a stimulus received by the cells of the nucellus, both above and below the embryo sac. Fertilisation of the egg cell is thought necessary for the formation of the nucellar embryos, while some are of the opinion that pollination alone is essential. Since neither spore nor egg cell is involved in this reproduction process, the additional embryos may in effect be regarded as due to adventitious budding, analogous to true vegetative reproduction. Thus, when the seeds germinate, only one may be a seedling from a true cross while the rest, numbering sometimes as many as ten, will not differ from the mother plant. If the sexual seedling can be distinguished and eliminated, a pure line of vegetatively reproduced descendants can therefore be secured through polyembryony. On a bulk scale in several *Citrus* it has been found that, when the variant seedlings amounting to about 10 per cent are rogued out in seed beds, the generative seedlings thereby get eliminated, leaving only the seedlings of vegetative origin. The generative off-springs generally show very poor growth, and in hybrids they are sometimes easily distinguishable on the basis of plant characters from the true-to-type vegetative off-springs. Apogamy or the production of seedlings from unfertilised embryos is, therefore, valuable in securing true-to-type progenies. It offers a method of raising from a single tree a much larger number of vegetative progeny than by budding or grafting.

VEGETATIVE METHODS.

There are numerous methods of vegetative propagation which are dealt with in extant literature. The reader will find especially the publications of the Imperial Bureau of Fruit Production (now Imperial Bureau of Horticulture and Plantation Crops) listed at the end of this chapter useful for reference. Some of the more extensively employed methods in South India will also be described under the respective fruits in Part II of this book. In this Chapter, therefore, only a brief reference is made to the methods of common application in South India, which have not been dealt with or only inadequately dealt with, elsewhere in this book.

(1) *Root cuttings* :—As the name implies, these are taken from the roots of plants which are intended to be multiplied. Each cutting may be from 2 to 10 inches long, and is planted usually in a horizontal position in soil or sand medium. Some prefer to keep the upper end of the cutting a little aobve the surface of the rooting medium. As the adventitious buds emerge from the soil or sand media, which is watered regularly after the cutting is planted, only one strong new shoot is selected and retained and the rest are removed. When the new plant attains a size fit for transplanting, it is shifted to the permanent site. Seedless breadfruit is propagated by root cuttings in South India. Guavas can also be done likewise, though the method is seldom practised commercially.

(2) *Stem cuttings* :—Cuttings from fully ripened wood are extensively used material for the propagation of many fruits. They may be made to have one to several buds and may vary in length from about 1 to 18 inches. Such cuttings may or may not have a heel of the older wood attached to them. The cuttings are usually buried to about three-fourths of their length in soil or sandy media in a vertical or slanting position and are made firm. A warm propagating frame for these and root cuttings is sometimes employed in cold regions, but such devices do not seem necessary under South Indian conditions. The cuttings may be free of all leaves or may have some or all the leaves on at the time of planting, up to the part buried in the soil or sandy media. Both these and root cuttings may be planted in flat nursery beds or in pots. In the latter case, the cuttings around the edge of the pots generally are found to root better than others. Grapes, figs and pomegranates are suitable subjects for commercial reproduction by hard wood and defoliated cuttings. In all these the cuttings may be made from

the joints or from internodes, but the former are preferred, as it is the common belief that rooting is better at the cut ends of the node rather than of the internode. Accordingly, it is the widespread practice to make the basal cut just below the node and the cut is usually given in a slanting manner with the hope that more of the root initiating region would be exposed thereby. The upper cut on the other hand, is given an inch or two above a node and at right angle to the main axis, in accordance with the belief that this would reduce the size of the wound to be exposed to sun and would permit less of injury to the topmost bud.

In some subjects difficult to root as the mango, cincturing the shoots from which the cuttings are to be taken, by removal of a piece of bark all around the shoots at the place of removal of the cutting, has been found useful. Over the cincture the shoot forms callus growth, and when the shoot is cut, prepared into a cutting, and planted in pot or beds, with the callussed part buried in the soil, rooting is facilitated. Large callus growths at the base of cuttings may, however, delay rooting. In such cases a part of the callus may be removed by a sharp knife before planting. Some success has been achieved at Kodur by planting cinctured cuttings of the mango, and it is reported that cinchona also, responds to a similar treatment in South India.

Chemical and hormone treatments or application of growth regulating substances have also been used to facilitate rooting in otherwise refractory material. The hormones usually advocated are phenyl acetic acid, Indolyl acetic acid and naphthalene acetic acid. Brewer's yeast as a source of vitamin B complex has also been used to increase rooting. Work in hormone and chemically treated cuttings has not been done with South Indian fruits to any extent. A few rough trials at Kodur with two proprietary hormone preparations proved of little or no avail with the mango.

Planting of semi-ripened and soft wood cuttings as are used with drumsticks and coleus respectively, of large limb cuttings as those employed with *Erythrina indica*. and of single eye cuttings with or without heel as is sometimes used for multiplying rare varieties of grapes etc., are not of much commercial significance in South Indian fruit nursery practices.

The advantages of propagation by cuttings are that. the method permits the raising of larger plants from a mother tree in a given time than by seed, and that the rooted cuttings are true to the parent, unlike the monoembryonic seed progeny. It is however, widely believed that the roots from a cutting spread out irregularly and more or less horizontally, producing what is popularly known as "duck-foot" rooting. This shallow or surface feeding root system associated with the propagation by cutting may not help the tree to have a strong hold on the soil or to utilise the lower layers of orchard soils to that extent as the deep rooted seedling trees are capable of.

(3) *Layering* :—When a branch, stem or shoot is made to root *in situ*, the process is termed as layering. The method is economical only when the material to be layered is close to the ground, so that it may be buried in the soil or in the pot placed on the ground. In other cases the pots have to be raised and kept on specially improvised structures to enable the selected parts of the tree to be layered. This and the subsequent watering of the layered shoot are expensive. To induce rooting the selected tree part has to be generally treated in some manner before burying in the soil, although in some trees like the lemons the shoots root readily without any treatment but merely in contact with the moist soil. The usual treatment for inducing rooting is to slice or ring the shoot, limb or stem. A method of layering devised at East Mall-

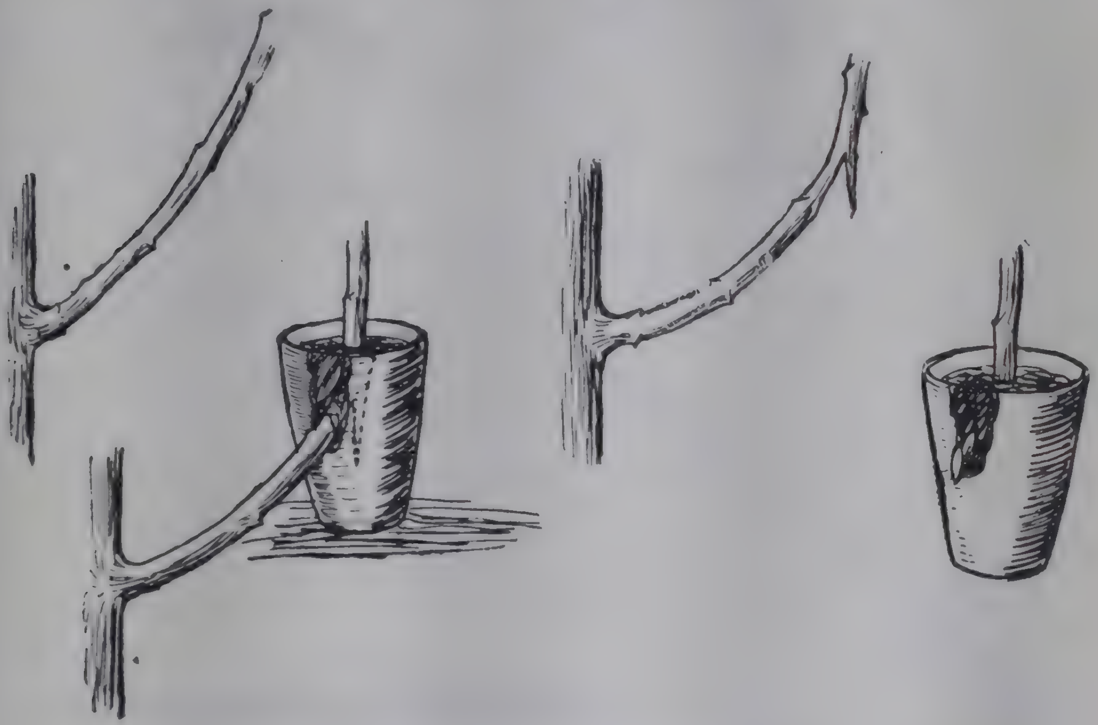


Fig. 6. Layering by slicing of the shoot.

ing in England is known as the etiolation method and has been found useful in South India also for rooting certain plants used as rootstocks for apples. In this, about one-year-old plants intended to be multiplied are planted in a slanting position forming

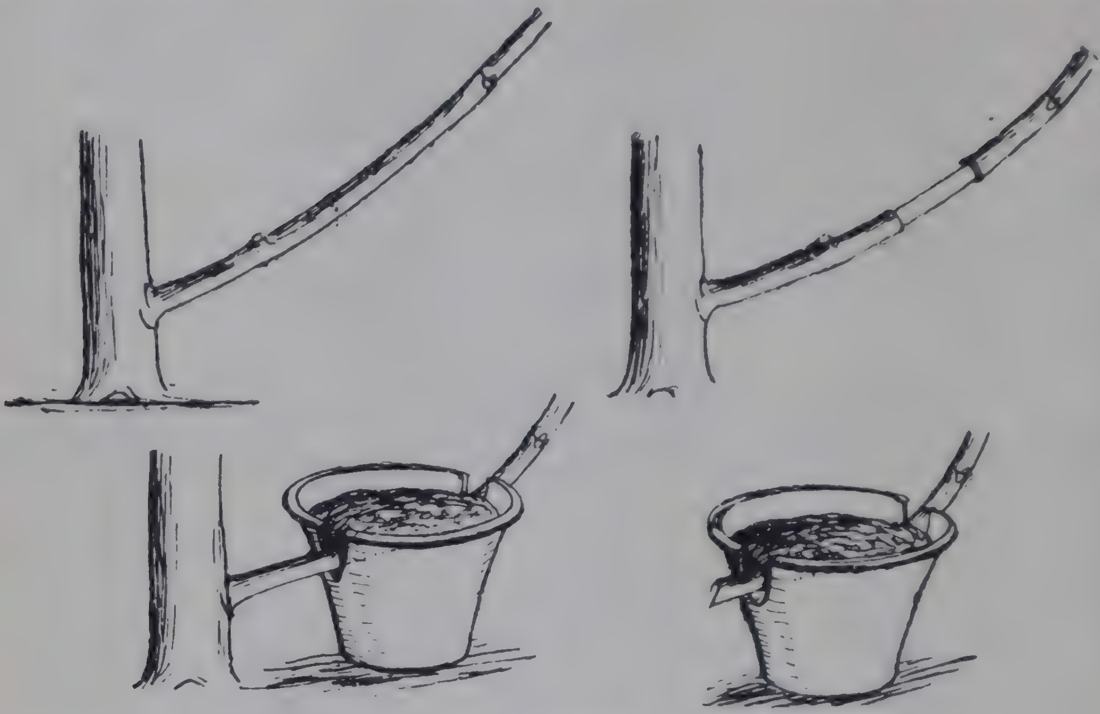


Fig. 7. Layering by cincturing.

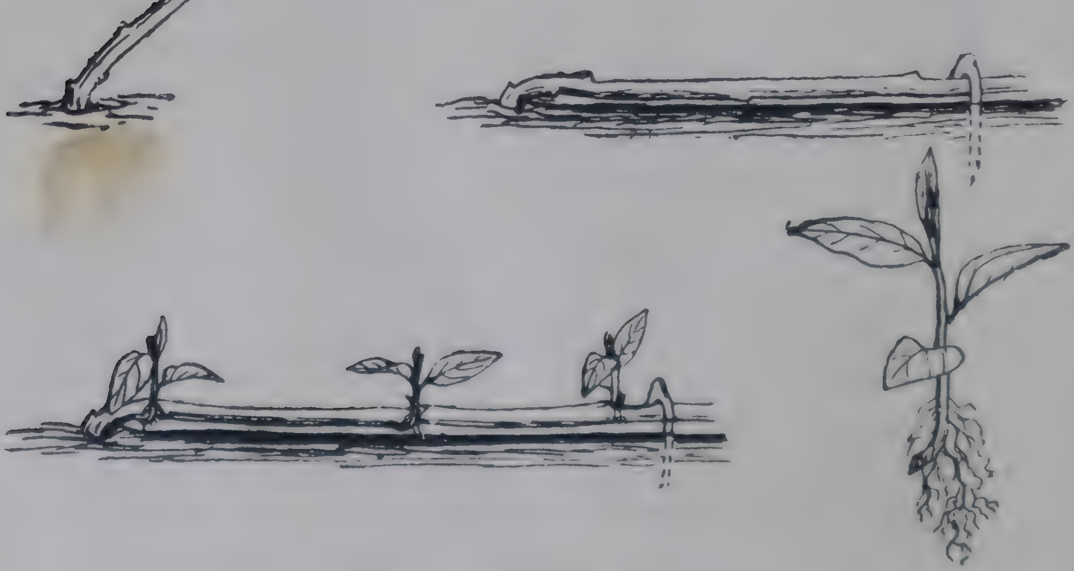


Fig. 8. Etiolation method of layering.

an angle of about 40 degrees to the ground. When the plants are established in this position, they are bent over and pegged down in a shallow trench and covered with a thin layer of soil. As the buds begin to swell along the buried parts of the stem, more soil is thrown over the stem gradually. This process is continued as the new shoots grow up and till the soil covering is about six to eight inches deep. The covered parts of the new growth are thereby kept in the dark, as a result of which they become etiolated. From these blanched parts roots emerge, and the rooted growths are finally detached and planted out, leaving sufficient numbers on the parent plant for the formation of future layers. Thus, the layering beds when once established become more or less permanent, producing a succession of plant supply. With evergreen plants, earthing up has been recommended only after the new shoots are allowed to grow several inches above the ground. If covered too early, it is said that the shoots are likely to die. In some cases rooting has been assisted by binding a wire round the new shoot near its junction with the parent plant. The wire should be wound not so tightly as to cause bark injury, but only in a manner that would permit the wire to penetrate the bark as the process of swelling of the shoots progresses. The cincturing caused by the wire provides a stimulus to root formation.

Stooling is a modification of the etiolation method, in which the plants to be multiplied are cut back first to almost the ground

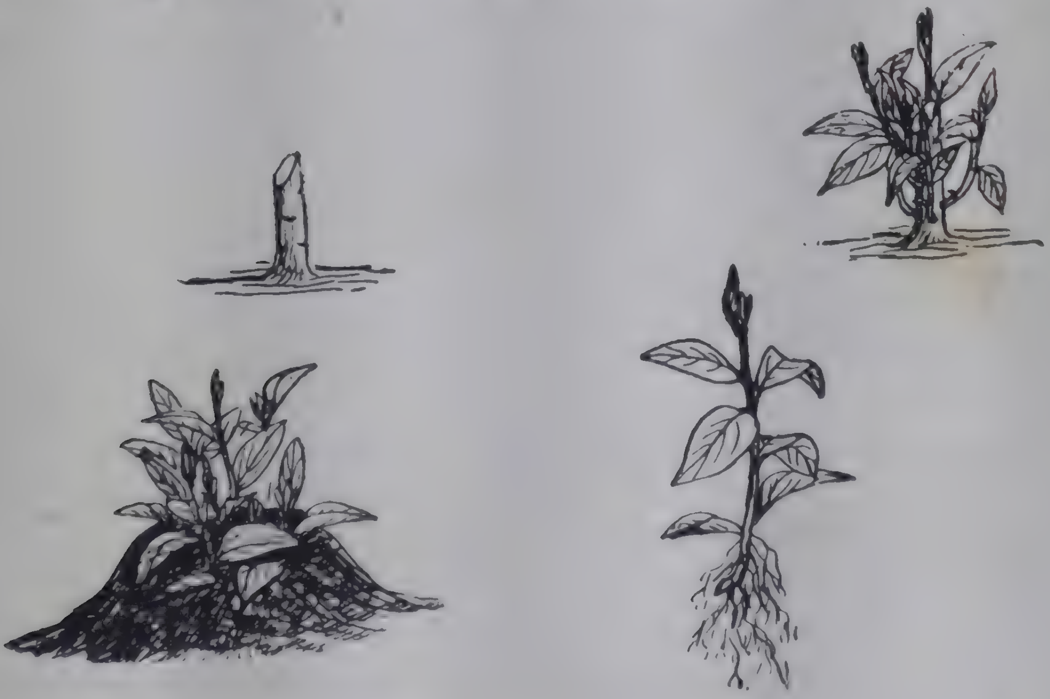


Fig. 9. Stooling as applied to cinchona.

level. The fresh growths which result are etiolated by heaping earth around them gradually as they grow up. The new shoots are thus buried gradually up to not more than about half their length. After rooting they are detached as explained already and planted out.

An important difference between these two methods and the layering method commonly practised in South India is that, large trees are not used as mother trees in the former case. Only apple rootstock varieties are being layered by etiolation methods in South India, while by the common layering method, guava, sapota, lime, lemon, fig, grape, litchi and cashew are some of the fruits that are being propagated to greater or less extent. The common layering method, excepting when naturally formed layers are produced in contact with the soil, is a tedious and expensive method, the cost on watering the layered shoots being large especially when done in pots. If the pots are buried in the tree basins which receive irrigation water, the cost on watering the pots can be greatly minimised.

Like the rooted cuttings, the layered plants are generally believed to possess a shallow and horizontal root system, and are free of tap roots, but they possess the merit of reproducing plants true to the mother tree. Production of true-to-type, own-rooted trees is not possible either by seed or grafting. Layerings and cuttings are of particular value therefore for raising uniform rootstock material. A deep rooting habit with long tap roots is also considered less suited for planting in soils with high water tables than the shallow rooted layered plants or rooted cuttings.

(4) *Gootee* :—The method of raising trees by gooteeing or marcottage, as it is called in some countries, is a modified form of layering. In this method the shoot is wounded or ringed and is then surrounded at the ringed or wounded part by earth, moss or similar material to induce root formation. A gunny piece is generally wrapped over the covered part in South India, while elsewhere a container or a pot divided into two equal halves lengthwise is sometimes used to inclose the gootied part and this is filled with the rooting medium, and is securely tied around to hold it in position. The treated shoot is kept moist by an ingenious arrangement, by which the rooting region is fed with moisture by a string passing through a bottom hole of a pot tied in a convenient position above the treated shoot and is filled with a constant supply of

water. The lower end of the string touches the gootied part of the shoot. The moisture from the pot trickles down through the hole and along the string to the rooting medium. This arrangement is not felt necessary if the gootee is prepared in the monsoon in humid and heavy rainfall tracts. Frequent syringing of water through a fine rose to the gootied parts in dry weather serves also a useful purpose. The roots emerge from above the ring or wound, and when well developed the rooted shoot can be detached and planted out. If a container or pot had been used for enclosing the gootied part, the successfully rooted shoot can be kept in the pot itself till the time of planting. At the time of planting the two halves of the container are separated out, while in the gunny wrapped plants the wrapping material has to be uncovered gently.

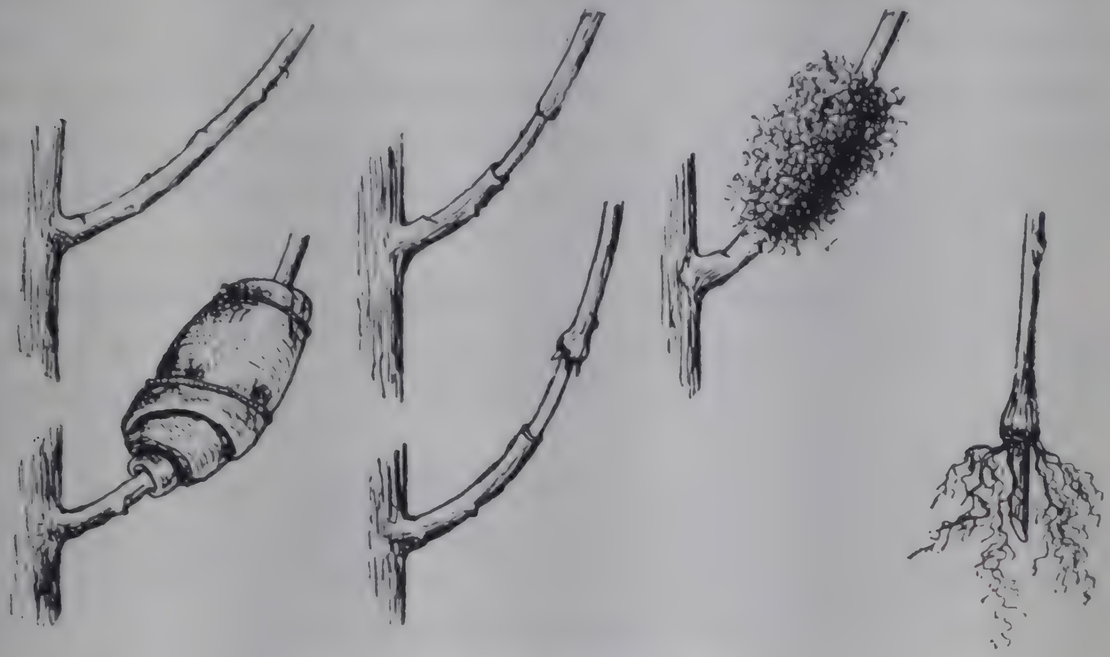


Fig. 10. Marcottage.

Gootee is also a tedious and inconvenient operation as the common method of layering. It is applicable to all plants which respond to layering.

(5) *Runners* :—Runners are parts of mother plants, each of which is capable of producing roots in contact with the soil even when connected with the parent plant. They are separated from the mother plants prior to planting. The strawberry is raised easily by its runners.

(6) *Offsets or suckers* :—These are leafy shoots produced from adventitious buds generally on the underground parts of plants, but occasionally also from positions above the ground level as in the

date palm. In pineapple the suckers or offsets emerge out at the base, along the main axis below the fruit, and underneath the crown or tuft of leaves on the fruit. The plants arising from the roots of guavas and citrus trees are also called suckers. The suckers or offsets can be detached with or without a portion of the root, if present, and planted out. By making cuts to the roots of the mother tree, it is possible to induce sucker formation in guavas, and possibly also in citrus, but such a procedure is likely to affect the growth and performance of the mother tree.

The suckers emerging out of the banana corms provide the chief planting material in that fruit. Even pieces of the corm with a growing bud can be used as planting material in banana, though this is seldom done.

(7) *Clumps or splits* :—In some cases the mother plant is divided into several daughter plants near the collar, and each split or a part of the clump so detached can be planted out to raise new plants. Strawberry is easily multiplied by this means also.

(8) GRAFTING

So far the propagation methods in which only the mother plant or a part of it is involved, have been dealt with. Grafting and budding are more complicated methods, in which the ultimate tree is the result of bringing together separate entities, known as scion and rootstock. That part of the mother tree which is used in grafting and budding to develop the future tree is the scion, occasionally also called as cion. The plant or part of it on which the scion is worked upon to produce the final tree is the rootstock, or as it is often called the stock.

There are several methods of grafting and budding, of which only those of application or interest to South India are mentioned and described in this book.

(a) *Inarching or approach grafting* :—In this method of grafting the scion remains attached to the mother tree until the union between it and the rootstock is complete. The plant to be used as the rootstock is grown separately and is brought near the scion shoot either in a pot or by planting it in the ground close to the selected scion shoot. If potted plants are used as rootstocks, they are placed close to the scion shoot by means of a specially erected platform or by means of other contrivances. One of these is the grafting-pot-stand devised at Kodur. Some are also using the cleft ends of a bamboo or wooden pole planted in the ground, for placing the potted plants. If the scion shoots are low-hanging, the potted plants can be placed on the ground. After the potted plants are placed in convenient positions, a small piece of bark with a part of the inner wood is sliced off to a length of two to three inches both from the scion shoot and the stem of the potted

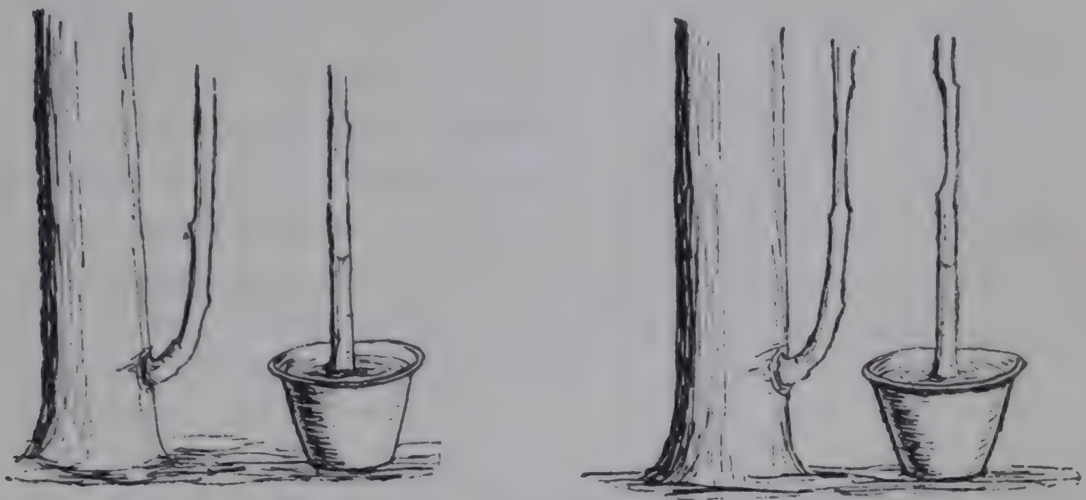


Fig. 11-A. Inarching, showing slicing out of the stock and scion.

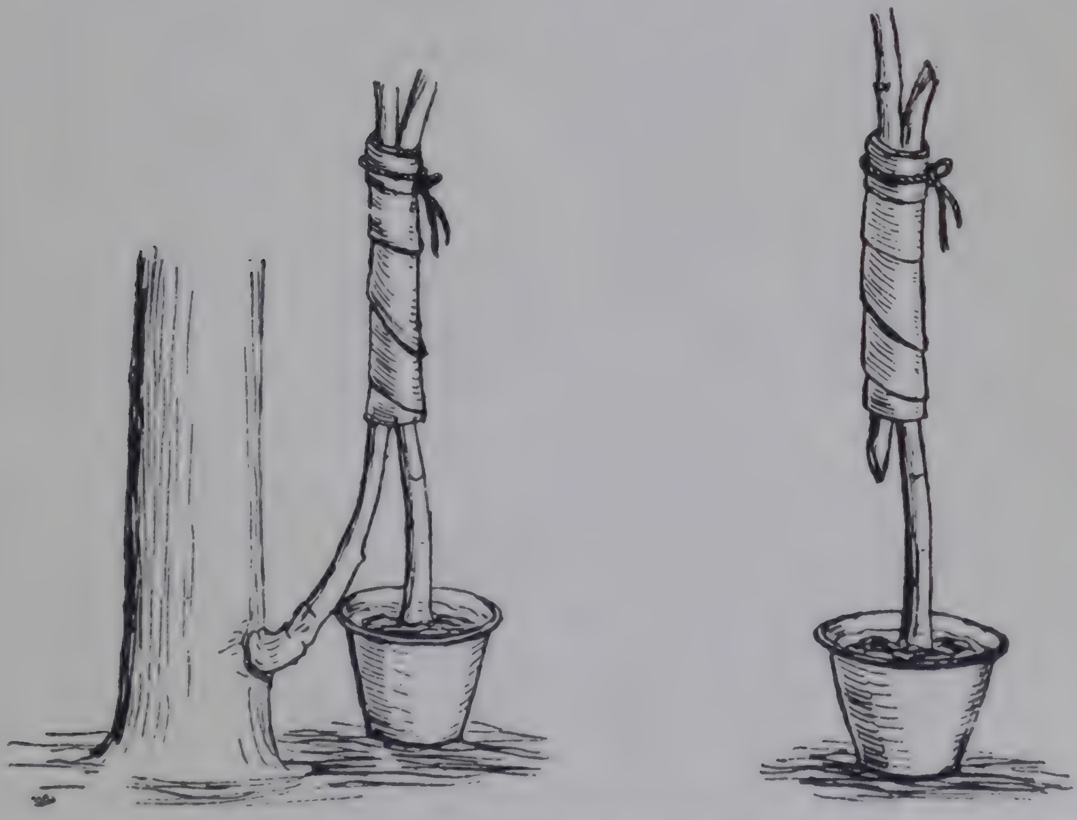


Fig. 11-B. Inarching, showing the tying of the stock and scion together.

plants, at the portions to be united. Before the slicing is done the position of the potted plant has to be adjusted so as to ensure easy contact between the two entities to be sliced. The cut surfaces of the two are then brought together, so that the cambia are in perfect contact. Such a contact is only possible if the scion shoots and the stem of the potted plant are of the same form and thickness at the cut portions. As soon as the two entities are held together with the cut surfaces in contact, they are bound over in the same position by fibre, string, raffia or waxed cloth. Over the bandaged part, a poultice or mixture containing usually one part of red earth or loam, one part of clay, one of sand and one of cow dung is applied. But now-a-days many nurseries in South India use only paraffined cloth without any poultices. Grafting wax may also be applied instead of mud poultice, after preparing in several ways, mostly after mixing with different proportions of rosin, bees-wax, tallow or linseed oil. When the union is complete in the course of two to four months in most plants, the scion is separated out from the mother tree just below the point of union in gradual stages, which involves the giving of a cut about an inch or two below the union and half-way through the shoot once in about a month of the inarching operation, and another on the opposite side an inch further up about a fortnight before the final separation. The rootstock stem is also lopped off at the same time above the point of union. Some persons prefer to do the lopping of the stock stem, at the time of inarching itself, in which case the seedling looks as if it is prepared for whip-grafting. The method of inarching as applied to the South Indian mango is more fully dealt with in Chapter II.

In the case of some trees affected by bark diseases at the collar, another method of inarching can be practised to renovate the bark. In such a case the seedling to be used as a rootstock is planted close to the diseased tree at an angle with the plant leaning towards the tree. After the plant is established, it is lopped off at a convenient height, and a portion of the bark and inner wood is sliced off to a length of two to three inches till the lopped extremity. This is done by means of a sharp knife which is to be worked upwards, gradually deepening the cut as the knife moves up. The exposed part of the plant is then inserted within the healthy bark of the tree above the diseased portion. More than one plant can be inarched in this manner all around the tree. When all these unite, the rootstock plants will grow, developing new bark in place of the old diseased bark.

Inarching can be done by not only using the stems but also the roots of the plants to be employed as rootstocks. This will be root grafting, which as applied to the mango, will be dealt with in Part II. Root grafting is said to lead to the production of more uniform plants than stem grafting. It also eliminates that part of the rootstock influence to which the stem piece of the rootstock may be responsible. In some fruits like the apple, grafting direct to the root piece saves the future tree from the woolly aphis infestation, since the stem of certain varieties is more susceptible to the pest than the root piece. With trees that have a tendency to produce scion rooting in orchards, root grafting, however, is a disadvantage as the scion portion cannot but be kept in contact with the soil in such grafts. Root grafting by other methods than inarching is also possible, whip grafting having been found specially suitable for the apple in South India.

Tongue inarching is a modified form of the method described above, in which instead of a smooth slicing off, the cuts are made in the form of a tongue in about the middle of each of the exposed surfaces. The tongue of the scion shoot is inserted within the cleft formed on the exposed wood of the plant to be used as rootstock, after which the tying is done. This method is not popular in commercial nurseries in South India.

Mango, sapota and guava are some of the major South Indian fruits that are raised by inarching. Although in all these the success lies in the main on the perfect union between the scion and the rootstock, for which the exposed surfaces should be of equal size, it is not uncommon to find sometimes the union taking place by sheer mechanical force of the contact. There are also instances of two or more young plants planted in the same hole, eventually joining together to form one trunk by such mechanical contact in Nature. The facility with which the union takes place in some plants has resulted in some carelessness in the inarching operations in the South Indian nursery trade, with the result that plants with weak graft-joints are often supplied to the public. Many instances of the breakage of such weak unions while in transit or when shaken in wind-swept situations, have occurred in the past, due to neglect by the operators.

Inarching has also been used to top-work inferior trees so as to convert them to superior fruit yielding individuals. A method of doing so in so far as the mango is concerned will be reserved for discussion in a subsequent chapter.

Inarching is a fairly simple and easy operation, though its application in root grafting and in top-working operations is expensive and tedious. Inarching, however, involves the use of large quantities of scion wood and is therefore less preferable to budding. The watering charges on the plants placed at different positions of the mother tree at varying heights from the ground level are heavy and this is an important defect associated with this operation. The presence of mother trees close to the nursery is also necessary to render the inarching convenient and easy of supervision. Though admittedly tedious and expensive in comparison to budding, inarching as a method has, however, been subjected at times to unduly severe condemnation. The theory advanced by some persons that inarched trees are short-lived and stunted in comparison with other vegetatively propagated plants is not based on fact as anyone conversant with hundreds of inarched mango plantations in South India will know, and is also disproved by the growth and performance of comparable batches of budded, side-grafted, cleft-grafted and inarched plants at Kodur. In many commercial nurseries in South India, experience has shown that inarching can be done cheaply, so much so that some grafts by this method are available in the market at Re. 0-4-0 each or sometimes even less. The low production cost is due to the adoption of several economic measures, such as the use of self-sown and spontaneously germinated seedlings for stock, bulk production, inarching with pots placed on the ground, use of scion trees specially trained to produce an abundant growth of low-hanging shoots, substitution of hill grass, cocoanut husk and coir containers instead of earthen pots, and burying of pots in the ground of the scion plantations so as to reduce cost on watering the plants from the inarching to the separation stage. In heavy rainfall tracts it is also found that if the inarching is done in the monsoon season, there is no need to water the potted plants on most days before the union is effected; and no watering is also done after the union is complete. Actual trials at Kodur have shown that the cost of producing budded plants or side grafts of mangoes is not always less than that of the inarched plants of the same fruit.

(*b*) *Side grafting* :—The method of side grafting as successfully practised at Kodur with the mango will be described in Part

II along with a modified form adopted in West Coast for top-working mangoes. Side grafting has also been tried with some success with fig, cashew, sapota and mangosteen on a small nursery scale in South India. The possibility of raising plants with scion wood obtained from a distance is a special advantage associated with this and the other methods which follow.

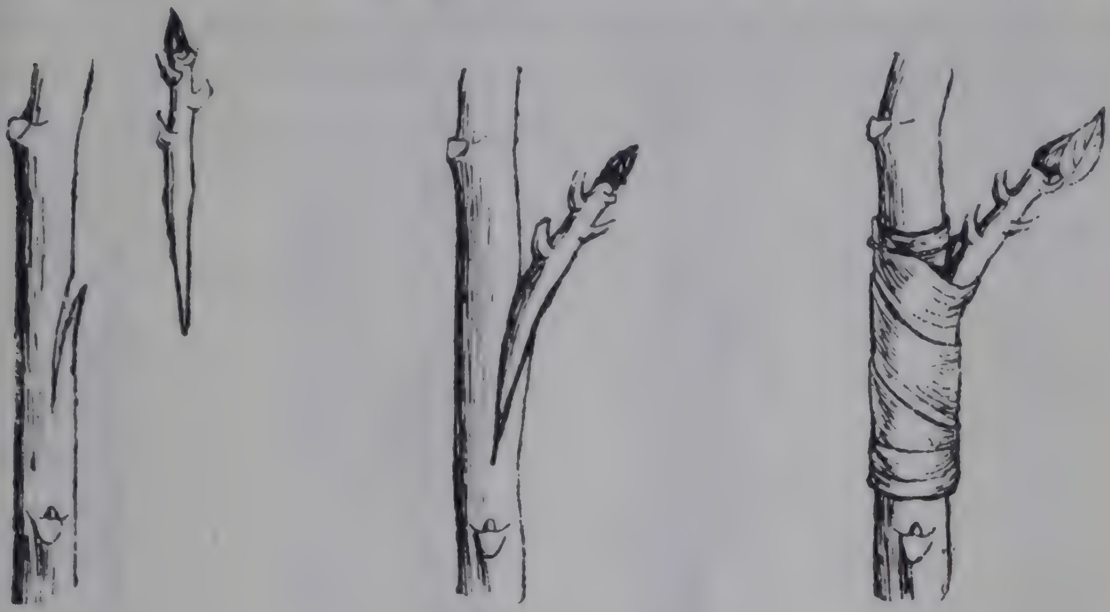


Fig. 12. Side grafting.

(*c*) *Saddle grafting* :—For this, the plant to be used as rootstock is cut first transversely and is then given two upward cuts on either side, the cuts deepening as the knife is pushed upwards.

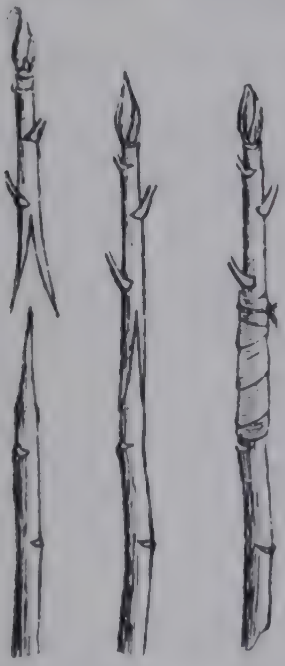


Fig. 13. Saddle grafting.

The scion is cut from the tree and a cleft is made so as to correspond to the exposed parts of the plant on which it has to be fitted. The scion is then fitted over the exposed part of the rootstock and is tied over and sealed by a mud poultice or grafting wax. The method is possible with apple and pears, but is not popular.

(*d*) *Whip grafting* :—This is a simple and extensively employed method for propagating the apple at Coonoor. The scion shoot is given a slanting cut about three inch long at the basal end. A corresponding cut is made on the plant to be used as rootstock. The cut surfaces are placed together to contact the cambial regions, and are then bound together and sometimes sealed with grafting wax.

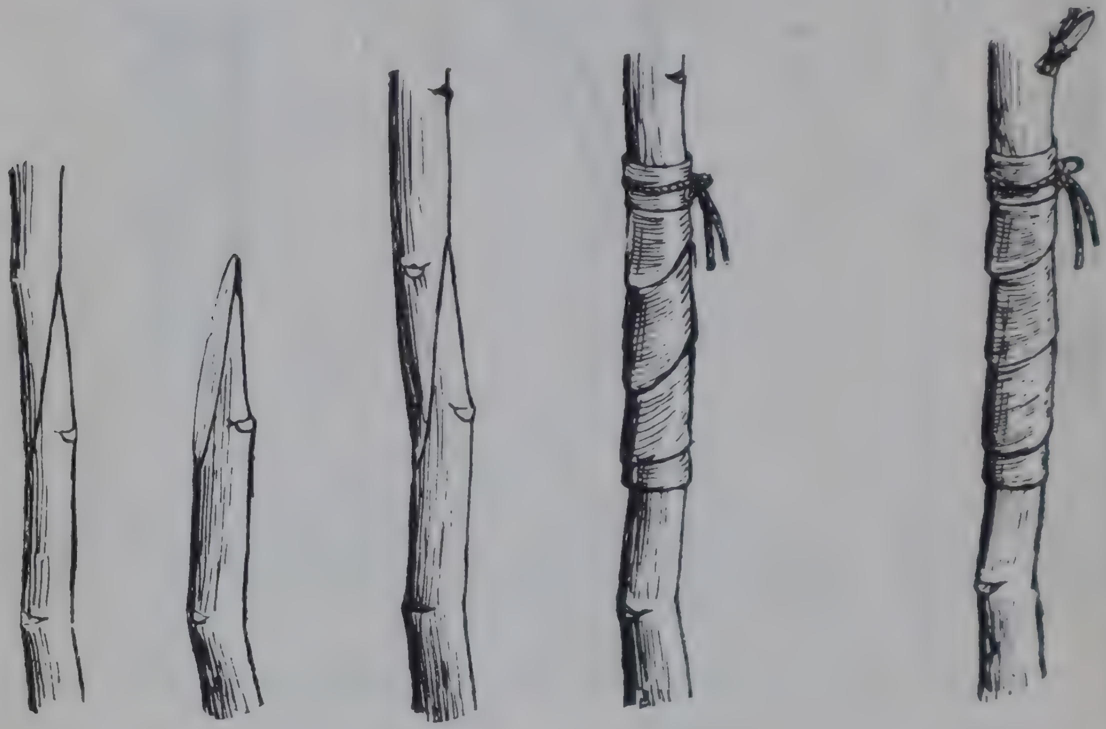


Fig. 14. Whip grafting.

Whip-and-tongue grafting is similar to the above, except for the making of tongue-shaped cuts to hold the stock and scion more tightly together. This is also practised occasionally with apple at Coonoor.

(*e*) *Cleft grafting* :—In this the scions are grafted direct on the root or stem portions of the rootstocks. The scion is prepared with its basal end in the form of a wedge while the stock is split at its upper end, in which the prepared scion is inserted. Tying and sealing follow. It can also be used for top-working apples and pears. For production of small nursery plants, cleft grafting is also found possible with the mango, although the success is very small.

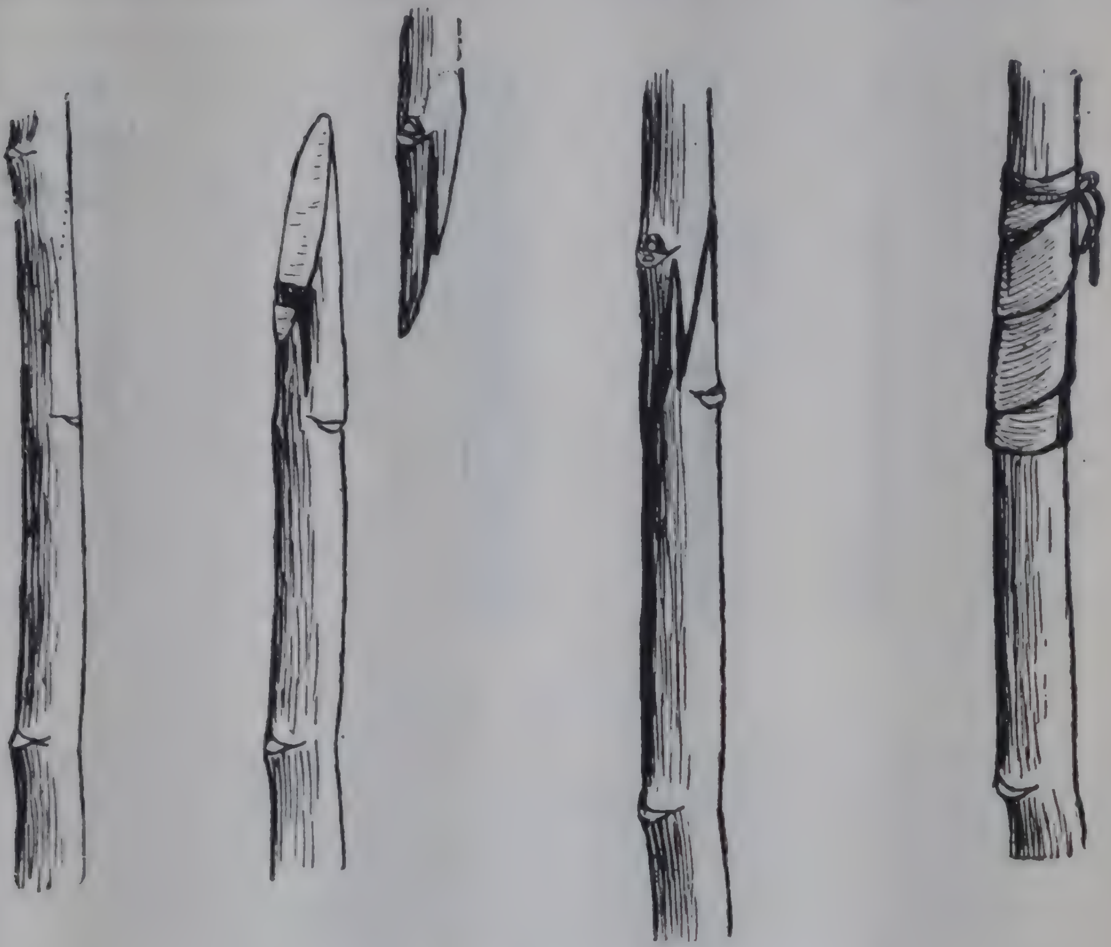


Fig. 15. Whip and tongue grafting.

(9) BUDDING

Economy in scion material is the special advantage of budding as a nursery practice. Of the several methods of budding, shield, flap and patch methods have been tried with varying success at Kodur for the mango and these will be dealt with later. The shield budding is of the greatest value in commercial citrus nurseries. That leaves only two methods of possible interest or value to South Indian growers and nurserymen for treatment in this chapter.

(*a*) *Flute budding* :—This method of budding is possible with plants whose buds can be removed with ease, because of the ready peeling off of the bark. Two parallel and horizontal cuts are made three-fourths to an inch apart on the scion shoot, completely encircling it. Between the encircled parts of the shoot and in the centre of it is the bud which is to grow to be the future tree. By winding round the end of a kerchief over the encircled region and with some practice it is possible to draw out the bud with the bark between the two circles intact. The bud with the surrounding bark has to be drawn out towards the terminal ends of the scion shoot, to facilitate which the shoot is cut off previously about an inch or two above the selected bud, and also the bark above the upper circle is peeled off to provide smooth passage for the fluted bud. It is also possible to give a vertical cut to the fluted bud on the opposite side of the bud and then remove the fluted bud by gently raising the bark out with the help of the ivory blade of a budding knife. Corresponding cuts are then made on the plant to be used as rootstock, and the bud is inserted on it. It is also possible to peel off the bark of the plant to be used as rootstock, after lopping, and push down the fluted scion bud after inserting it at the top lopped end. The pushing may be done carefully without damaging the bud, as far as it can go. In this case no tying is necessary ; but if the fluted bud has been removed with a vertical slit, tying is essential to secure a tight fit.

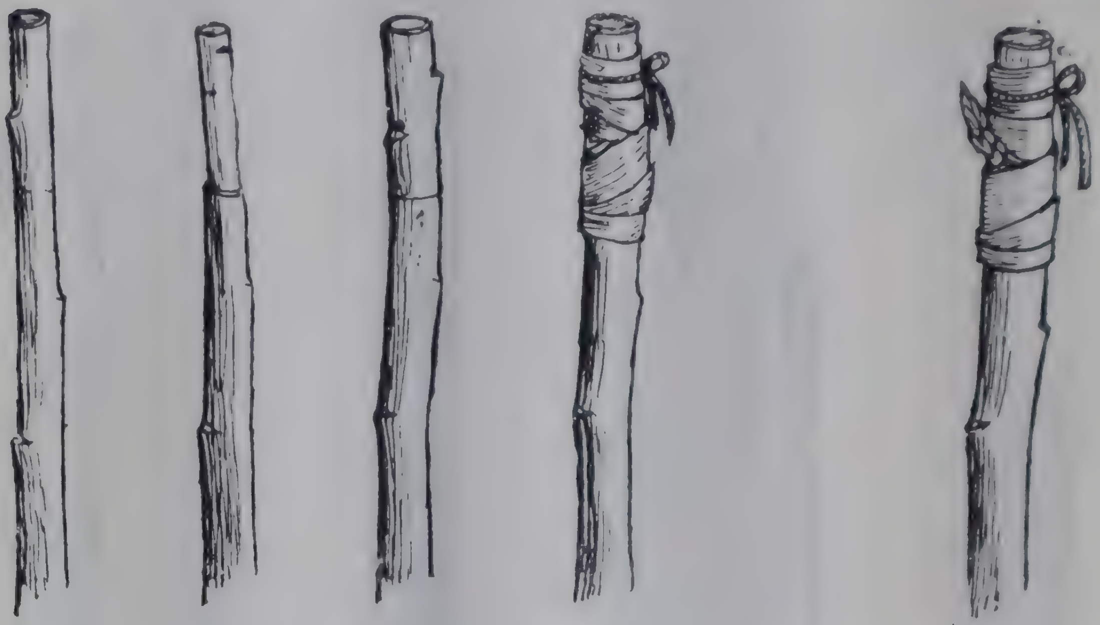


Fig. 16. Flute budding.

(*b*) *Yema budding* (*or bud-grafting*) :—This is a method that has been tried with some success at Kodur for propagation of the grape. A single bud with a large piece of wood attached to it is removed from the selected mother plant by giving a cut, as is illustrated in the accompanying diagram. Similar cuts are also given to the plant to be used as a rootstock, and the bud is then inserted and tied over, In all cases of budding the sprouts arising from the stem of the rootstock should be removed as soon as they arise. The rootstock stem above the bud-joint should also be removed after the bud-sprout has grown to about two to three inches. On thick rootstocks, the lopping of the rootstock stems may be done in two stages, once at the time of bud-insertion when only half of the stem of the stock is removed, and again after the bud-sprout has grown to two to three inches in length when the entire stock stem is removed up to the bud-joint. Budding can also be done for top-working old trees, either by working on new shoots, which can be induced to arise by cutting off some limbs, or by inserting in the old bark.

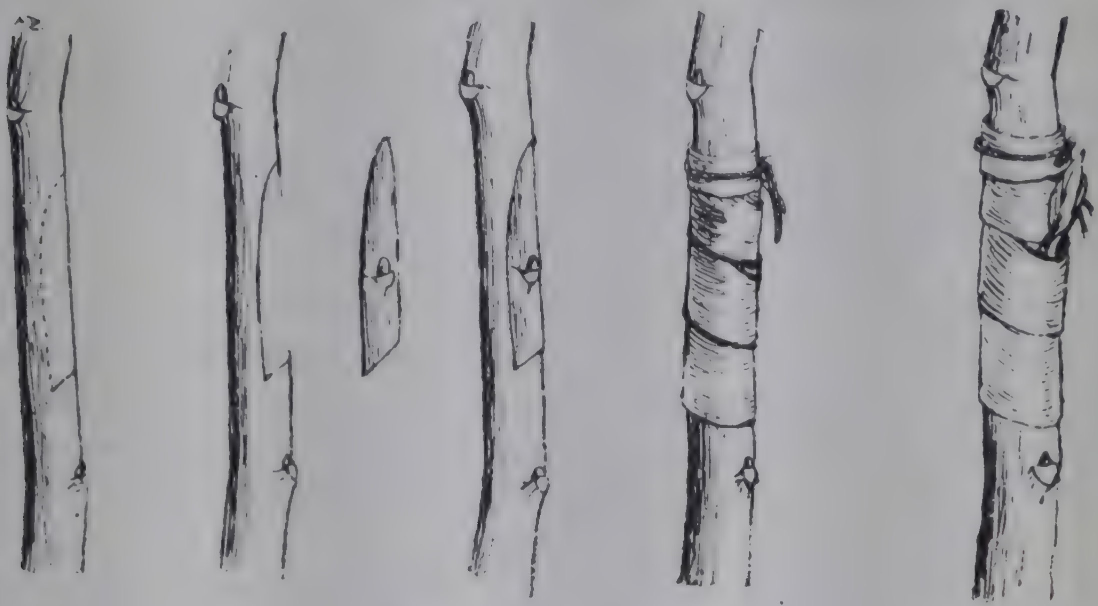


Fig. 17: Yema budding.

The subjects of tree and bud selection as well as other details relating to the production of grafts and budded plants are more conveniently dealt with under different fruits, and this is accordingly done in Part II.

ROOTSTOCK INFLUENCE

The influence of rootstocks is of such vital importance as to cause a great difference in the degree of success or failure of an orchard. The most important of the directions in which such influences manifest themselves are summarised below.

(1) *Stature* :—Certain varieties when used as rootstocks tend to produce dwarfed orchard trees. Pears raised on quince, apples on Malling IX, and sweet oranges on wood apple are typical examples of such rootstock influences.

(2) *Form* :—Rough lemon has the reputation of producing tall, upright sweet orange trees more than any other rootstock known.

(3) *Fruit maturity* :—Sweet orange fruits on rough lemon are said to be difficult to be retained on the trees as long as on other rootstocks. The trifoliate rootstock is also said to cause an early ripening in sweet oranges.

(4) *Hardiness* :—Citrus trees raised on trifoliate orange are reported to be hardier than on other rootstocks.

(5) *Disease resistance* :—The native American grapes are immune to *phylloxera* pest of the grapevines, while the European grapes are susceptible to it. Northern Spy variety is immune to woolly aphis and has therefore been extensively used as a rootstock in Mysore State for raising susceptible apple varieties on it.

(6) *Yield and precocity* :—Wood apple rootstock has proved at Kodur to induce the sweet oranges worked on it, to crop very early in its orchard life, and about three years in advance of the trees on other rootstocks. The yield of orange fruits on this and of lime on gajanimma have also been appreciably more than on other comparable treatments.

(7) *Quality of fruit* :—The quality of sweet oranges produced on wood apple has been the best so far produced at the Fruit Research Station, Kodur. Coarse and abnormally large sweet orange fruits are also produced on vigorous rootstocks like the rough lemon and gajanimma, especially in early years.

(8) *Longevity* :—A dwarfing and incompatible rootstock leads generally to shortened orchard life, while a slow growing and compatible rootstock tends to prolong the orchard life.

(9) *Vigour* :—The markedly better growth of scion trees of sweet orange on rough lemon and gajanimma and of poor tree vigour on wood apple provide proof of this aspect of rootstock influence.

Scion influence :—The reciprocal influence of scion on rootstock is less understood, because it is apparent to a lesser degree. The fact that mosaic diseases are transmitted by grafting and budding lead to the inference that mosaic-affected scions must be having a similar adverse effect on the rootstocks as well and *vice versa.* The scion influence on the size and number of roots, on their character and distribution, on their longevity and growing seasons and on their hardiness, may be expected to be profound, though exact knowledge on the subject is yet lacking.

Importance of rootstock selection :—A proper selection of rootstock and scion i.e., the optimum stionic combination is one of the means for success in orcharding. By choosing the right combinations, it should be possible to grow certain varieties on sites considered unsuitable for the same scion on another rootstock. It is also possible to secure better fruit and more fruit, more healthy and vigorous trees, longer-lived and hardier individuals by a judicious rootstock and scion selection. A notable instance of revival of the fruit industry of a country by selection of the proper rootstock is that of the viticultural industry in the United States of America. This industry which was on the verge of extinction due to the ravages of the *phylloxera* pest, was saved by widespread use of the immune American native grapes as rootstocks. In Mysore State the apple industry was given a new lease of life by employing Northern Spy (which is resistant to woolly aphis) as the rootstock for apples. The sweet and Vadlapudi oranges which are highly susceptible to certain stem and root diseases in high water table lands, may also find salvation if worked upon the shallow rooted or resistant citrus as the lime and sour orange respectively. It has to be noted, however, that the best rootstock for each fruit and in each tract or region has to be determined only by actual tests. Experiences of growers in many parts of the world have proved that a rootstock found best in a tract for a particular fruit leads sometimes to disastrous results in another tract or in a different soil in the same tract. The failure of sour orange as a rootstock for sweet oranges in South Africa and the success of the same in California are instances to the point. Even if the best rootstock is found out for a region or site, it does not eliminate the necessity to select the best parent tree both of the rootstock and scion. Selection of disease-free, healthy, good-yielding and vigorous trees as sources of rootstock or scion progeny is an important part of intelligent orcharding and nursery management.

Double-working :—A method of counteracting or modifying the rootstock influences is by double-working. It is for instance, wellknown that quince is either an incompatible or a dwarfing rootstock for some pears, while some varieties unite well with that rootstock. The device that is successfully adopted is to bud or graft a suitable or congenial variety on the quince, and over this graft is budded or grafted again the desired variety, which cannot by itself unite well with the quince. Double-working therefore may be useful not only to get over the lack of congeniality, but also to prevent a disease that is more or less characteristic of the rootstock trunk. It is also possible that the intermediate stem piece on which the scion is worked may impart its own rootstock influences such as quality, high yield etc., to the final orchard tree. Such influences have been indicated as possible at Kodur, where the naturally shy-bearing Jehangir mango has produced so far the largest blossom crop when double-worked on the prolific Neelum intermediate stem piece.

CONGENIALITY

Even after successful union, some scions fail to grow satisfactorily, while others produce only poor unions exhibiting thereby their obvious unsuitability to the particular combination. These unsatisfactory features associated with certain stionic combinations are attributed to what is called incompatibility or uncongeniality, or lack of graft-affinity between the rootstock and scion. The existence of incompatibility may be reflected by the formation of no union at all or only partial unions. In others, delayed incompatibility may be the feature, expressed by such symptoms as premature death of the scion growth, unhealthy scion growth, dwarfed scions or dissimilar growth of the component parts. Where the stock outstrips the scion in growth, a bottle-neck shaped graft or bud-joint is manifested. On the other hand, where the scion outstrips the rootstock the position is reversed. In both, the swollen graft or bud-joint is a manifestation of partial incompatibility, but this may also be due to unseasonal budding, deficiency diseases, defective propagation method or faulty manipulation in grafting or budding. If, however, the swelling occurs only in a few cases, it may be taken as a symptom of causes other than incompatibility. For practical purposes, stionic unions showing in majority of plants distinct failure to unite or to grow in a healthy manner or to live in the orchard for a long period, may be deemed as evidence of incompatibility. A few cases of abnormal union will not justify the stionic combination to be dubbed as incompatible.

There is no sure method of determining the compatible combinations except by actual test. Nearness of relationship within a species, genus or family does not by itself determine the degree of compatibility between the scion and the rootstock. If it were so, reciprocal grafts should not give dissimilar results, as they often do. Regional variations may account for some of the differences observed. In the determination of the best stionic combination for any tract, there is no short cut. Whether the rootstock is the limiting factor or the scion, or the union, it is only possible to decide after elaborate trials.

General requirements of Nurseries :—A fruit nursery is a very intensive type of farming and has to be maintained in such a manner as to enable the availability for sale of a wide variety of plants almost all through the year, in order to satisfy the fancies and requirements of a public of varied tastes and different regions. Success is only possible if the soil is of good texture and fertility and of perfect drainage, aided by an unfailing supply of good water for irrigation. Since the sale and despatch of plants and plant material is a regular item of work, it will be a great disadvantage if the nursery is located far away from a railway station. Distance would mean an additional cost on transport of plants, which the public cannot be expected to meet without demur. In the day-to-day working of the nursery, the skill of the operators is a vital factor for success. The difference between skilled and unskilled worker is often so great that it may make or mar the prospect of success. This fact specially applies to the field of vegetative propagation, in which some persons fail to achieve high skill even with prolonged training.

List of References

1. Angles, G. K.—A Review of Literature on Stock-scion incompatibility in Fruit Trees with particular reference to Pome and Stone Fruits, Imp. Bureau of Fruit Production, Tech. Communi. No. 9, 1937.
2. Fielden, G. St. Clair and R. J. Garner—Vegetative Propagation of Tropical and Sub-tropical Fruits, Imp. Bureau of Fruit Production, Tech. Communi. No. 7, 1936.
3. Imperial Bureau of Fruit Production—Investigations on the Standardisation of Citrus Trees by Propagation Methods, Tech. Communi. No. 3, 1932.
4. Naik, K. C.—Some Citrus Nursery Technique Trials at Kodur, Indian Journal of Agricultural Science, August, 1939.
5. ,, Studies on Propagation of the Mango, Indian Journal of Agricultural Science, October, 1940.
6. ,, A Study of the Pre-orchard Life of Certain Rootstocks for Chinee Orange and Acid lime at Kodur, Indian Journal of Agricultural Science, August, 1940.
7. ,, Some Useful Orchard Equipments Devised at Kodur, Madras Agricultural Journal, March, 1940.
8. ,, Purchase of Mango grafts, Villagers' Calendar and Guide, Madras, 1943.
9. ,, Vegetative Propagational Methods and Their Relation to Tree Performance in the Mango, Indian Journal of Agricultural Science (In Press).

10. Naik, K. C.—Top-working of the Inferior Mango Trees, Madras Agri. Dept. Leaflet No. 100, 1942.
11. ,, South Indian Mangoes, Madras Agri. Dept. Bull. No. 24, 1941 (Revised Second Edition, 1948).
12. Shamel, A. D.—Bud Variation and Bud-selection, The Citrus Industry, Vol I, University of California Press, 1946.
13. Wickson, E. J.—California Fruits and How to Grow them, Pacific Rural Press, San Francisco, 1926.

CHAPTER IV

PLANNING, LAYOUT AND PLANTING

Clearing and levelling:—Having selected the site for an orchard the first step is to clear the land of all vegetation. The standing trees and shrubs have to be removed without leaving stumps or main roots. In clearing the land many prefer to cut down only such standing trees as are in the spots where fruit trees are to be planted, leaving the felling of other trees to a later date. This is both wrong and risky. Standing trees with their extensive roots will continuously impoverish the soil, rendering the establishment or development of the young fruit plants difficult. They also shade the fruit trees near them. When the removal of the former becomes unavoidable at a later stage, there is the danger of the falling trunk or branches damaging the young fruit plants. Such old trees therefore should go along with all other bushes and unwanted vegetation as soon as the site is decided to be allotted for the fruit. The land is then given a thorough tillage and levelled. It is often difficult to correct the defects in the level and to remove deep-rooted weeds after the fruit trees are planted. There is also no scope for deep ploughing the land in established orchards, and this operation is therefore best done prior to the planting. Levelling of the site is important for several reasons. It will facilitate economy in irrigation and prevent soil washing. In an undulating site such levelling may involve considerable shifting of soil, in which event it is advisable to divide the site into two or more sections, and level each section separately putting at the same time a strong bund between each section. In slopes or in rolling ground, the terracing is the most important work to be attended to after clearing, unless the planting is intended to be done on contours. This has to be followed up by the formation of diversion channels, bunds and drains, all of which should be completed before the rainy season, to avoid surface erosion.

Green manuring :—Growing of a leguminous crop like sunnhemp (*Crotalaria juncea*), indigo (*Indigofera anil*), *pillipesara* (*Phaseolus trilobus*), cowpea (*Vigna unguiculata*), horsegram (*Dolichos biflorus*), *dhaincha* (*Sesbania bispinosa*) etc., in the cleared land is the next step. This is essential not only to improve the organic content of the soil by green manuring but also to indicate to the grower any weak or unsuitable spot on the site. In a freshly cleared land such spots may be many, and they may be due to alkaline or saline patches, or defective levelling caused by inadequate filling up of pits and depressions, or ill-drained or rocky patches. All such defective spots should either be corrected as soon as the green manuring is completed, or avoided for fruit planting.

Planning the orchard:—Preparation of an accurate plan is an essential part of the work of establishing an orchard. Few growers realise the importance of an accurate plan. Planting fruit trees in the available area with plants obtained from any available source and at any time will result in an orchard, neither pretty to look at nor profitable to maintain. With a carefully prepared plan, the grower is able to provide for not only the most economic orchard management but also for the economic layout and location of roads, drains, irrigation channels, hedges, wind-breaks etc. In the preparation of the plan a good knowledge of the fruit tree requirements and of the site is necessary. The prospective orchardist must know what fruits to plant and on what specific parts of the ground, before he can layout the area. The important points to be considered in the preparation of the plan are that, (1) the future orchard should present an attractive sight, and (2) it should be very economical to manage. Since the plan for each site is to depend on the peculiarities of the same, it is impossible to suggest a standard plan for any region. However, the following points have to be borne in mind, even though all of them may not be strictly applicable to many sites.

(*i*) The orchard should as far as possible present a beautiful panoramic view at the main entrance, with the back-ground in harmony with it.

(*ii*) The evergreen fruits are best planted in the front, and the deciduous trees or those that partially shed leaves in some season, at the rear.

(*iii*) The shorter trees may be assigned space in the foreground and the taller trees may occupy the rear. Such gradation will facilitate watching of the orchard.

(*iv*) With the same object, fruits that ripen at one time should be in contiguous plots.

(*v*) Irrigated fruit should be planted close to the irrrigation source and the rain-fed fruits kept farther away.

(*vi*) Fruits that attract birds and other animal pests and are prone to damage by them, should be close to the watchman's shed or hut.

(*vii*) Richer sections of the orchard area should be devoted to more paying and gross-feeding fruit trees.

(*viii*) In allocating sites for each fruit, due provision should be made for the planting of suitable pollinating varieties, so that optimum crop set is ensured.

(*ix*) The spacing adopted for each fruit should be the optimum.

(*x*) Wind-break belts and live-hedges should be assigned sufficient space and be far away from fruit tree areas, so as to avoid interference with the development of the latter.

(*xi*) Roads should be laid out in a manner as to occupy the least space, but at the same time to ensure economy in orchard transport and supervision, and to bring out to the visitor the best scenic views of the orchard.

(*xii*) The drains should be as far as possible concealed from the visitors, and should be laid out in a manner to serve the needs of every plot or area in the most economic and efficient manner.

(*xiii*) The orchard should be planned according to the purpose to which it is intended.

HOME GARDENS vs. COMMERCIAL ORCHARDS

The last point mentioned above leads to a discussion of the peculiarities of the two main types of fruit-growing prevalent in South India. A vast majority of people raise some fruits in the limited areas available to them around their residences. These home gardens are intended primarily to provide a continuous fare to the residents of a variety of fruit ripening in succession all through the year. Such gardens are essentially a combination of pleasure-ground and utility, in the layout of which individual fancy or taste of the owners play a dominant part. They are more or less similar to a plant museum with a collection of fruits of varied kinds and varieties, and with vegetables occupying a prominent part of the intercropping in the fruit areas, and with flowers and ornamental plants studded on the outskirts and along the roads to add to the beauty. Economy or profit does not enter into the calculations of the owner in the layout of the home garden. Separate areas for each fruit are rarely allotted. Care in the selection of the most appropriate site for each fruit is not always possible, as the owner has to make the best use of what exists. The area being generally limited, the fruit trees are not usually given the optimum spacing, and planting is often irregular. There is not much scope for the use of labour saving devices and implements, and much of the work in the fruit areas is left to be done by hand tools. The kinds and varieties of fruits are not chosen with an eye on profits or size of yields but more to please the fancy and palate of the owners. Home-garden fruits may make occasional appearance in the markets, but from the point of view of the consuming public, they are not reckoned as of any great importance. However, the fruit cultural practices in the home garden have to be more intensive than in a commercial orchard, and more attention is necessary for the individual plant.

The commercial orchard, on the other hand, is raised solely for profit and to meet the demand of the public. The success of these plantations is measured by the extent of profits realised. They are extensive, and are planted to kinds and varieties which are dependable croppers and of a type, the produce of which is in large and ready demand. Selection of the site has to be done with care for each variety or kind of fruit. The planting is regular, with adequate spacing for each fruit. Labour saving devices and implements are essential to keep down the production costs. Although the individual tree or plant may not receive as much attention as in the home garden, great care has to be bestowed in the selection of varieties and kinds of fruits, so that only the hardy and prolific ones, which need relatively less attention, are planted. The owner's personal taste has no influence in the selection of fruit. Above all, the commercial orchardist has to be a skilled and intelligent person with a love for his profession and capable of bestowing whole-time attention to his orchard.

LAYOUT

Both for beauty of the orchard and for its economic management, fruit trees should be set in straight rows. Three systems of planting the trees are recognised, of which only one is the most popular in South India. This is the square system in which all the trees arc set at right angles to each other. The trees planted on the square are not equi-distant from each other, due to which some have argued that a portion of the ground in the alleys is left unused.

This is incorrect, since in a good site and in a properly spaced orchard, the adult tree sends out its roots to cover the entire space.

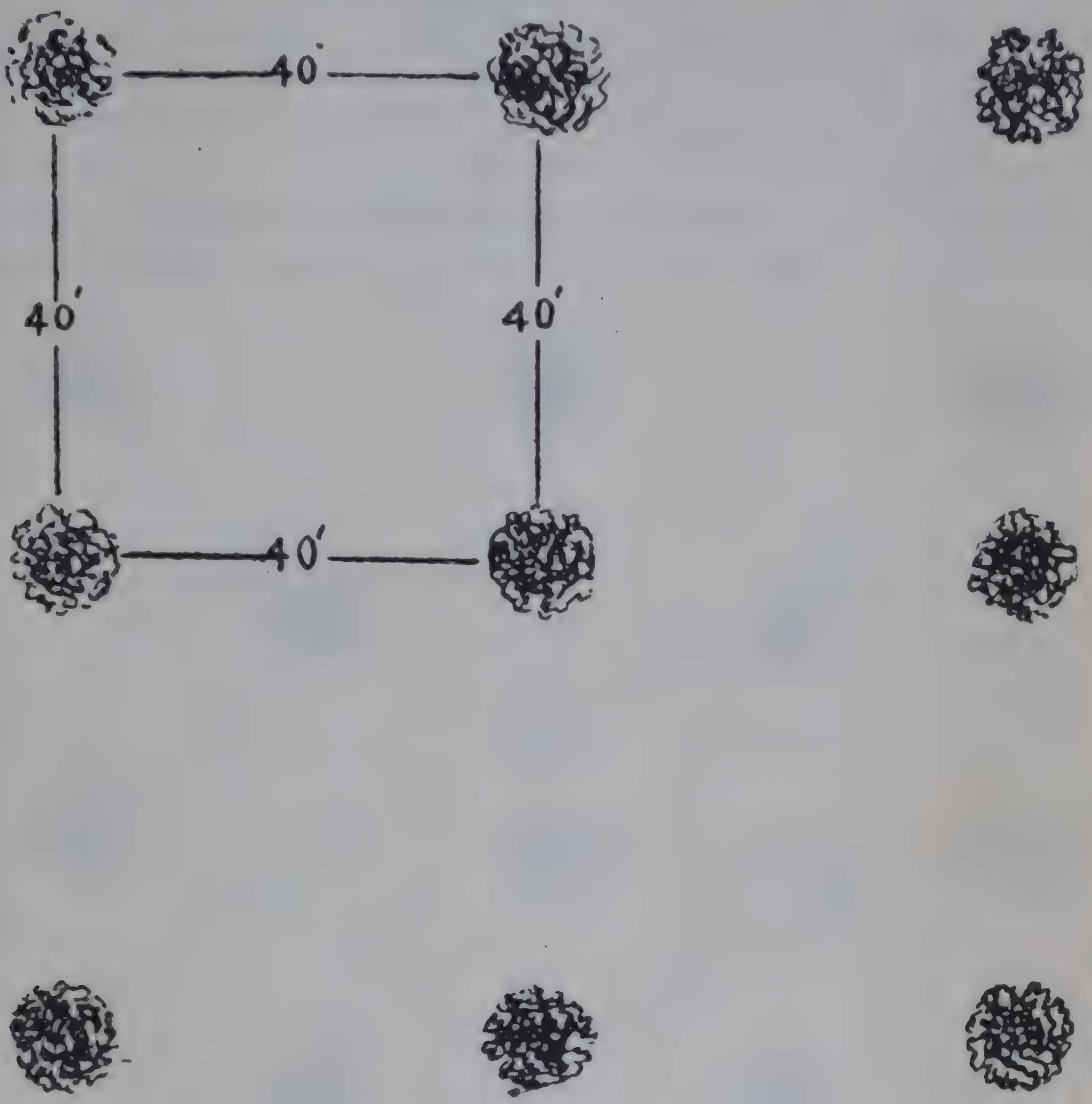


Fig. 18. Square system.

The square system of planting is very simple in execution and permits the raising of filler trees in the centre of the alleys. When the two sides of the square are lengthened, the system becomes rectangular or an oblong system. To layout the orchard to this system, it is advantageous to first start with the laying out of a base line at a pre-determined distance from the wind-break, live-hedge or fence line and from the road or drain. The distance from the fence, wind-break or live-hedge should not be less than forty feet for tree fruits. If less space is to be allowed, a trench of three to four feet depth should be dug in between. The base line is to be the first tree row. On this line, the position of each tree may be peg-marked. From the first peg at either end, a line may be laid at right angles to the base line. This can be done by laying out first a triangle with 60 feet on the base line, 80 feet on the proposed line to be laid out at right angles to it and 100 feet between the pegs at the 60 and 80 feet limits. When the three pegs are in their right positions, the new line can be extended easily with a rope to the extent necessary. On this line the tree positions can now be peg-marked, with the help of a tape. On reaching the last peg, another line at right angles to the second line can be laid, by first forming a triangle as before. Having thus formed three lines, it is easy to fix all the other pegs to mark the tree locations in between the lines at the required spacing, by using ropes and if necessary some bamboo poles to guide the workers in connecting the pegs of the lines in opposite directions. The square method of planting is almost universal on flat ground in South India, as already mentioned.

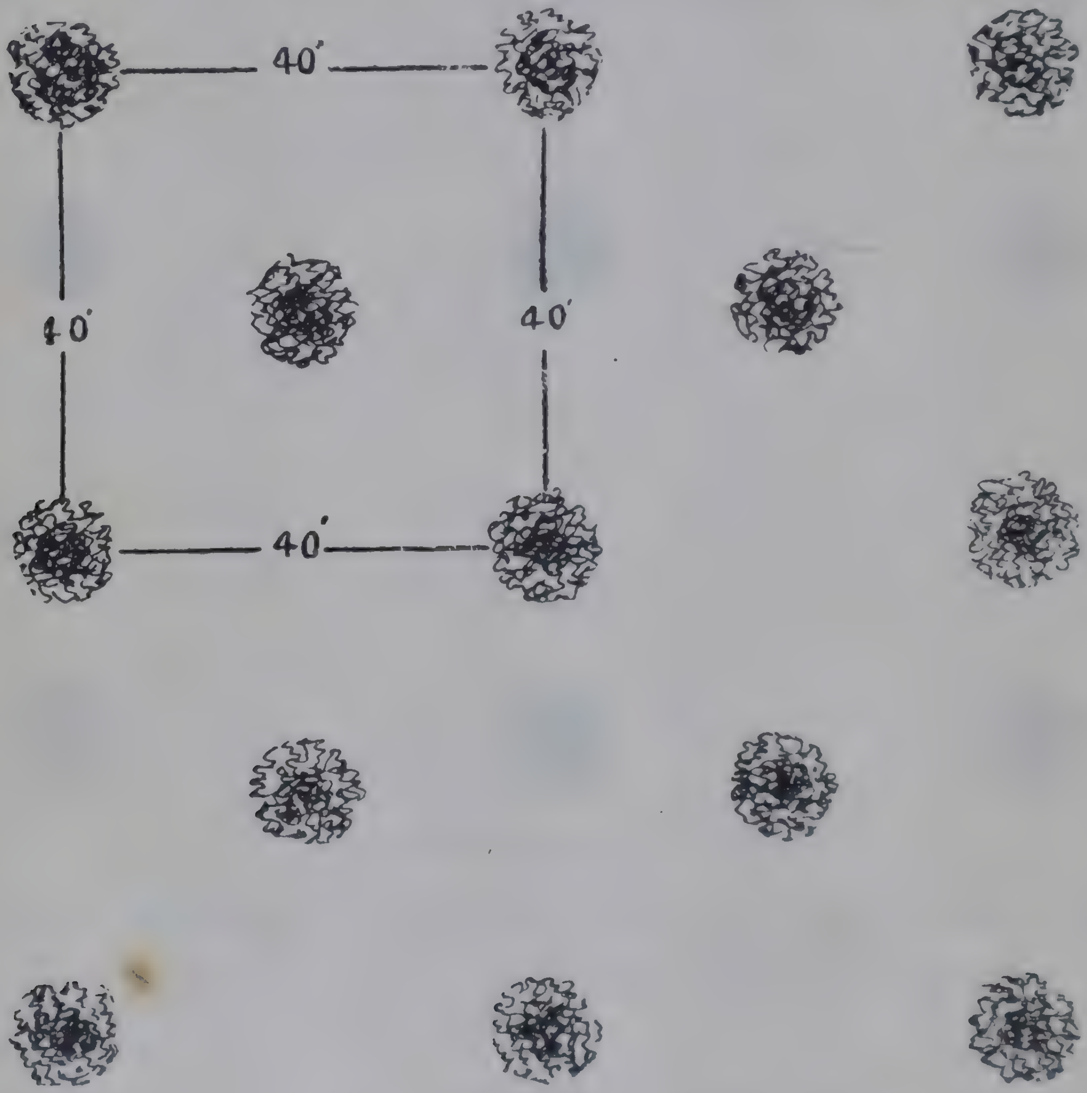


Fig. 19. Quincunx system.

The second method is the quincunx, according to which a fifth tree is set in the centre of the square formed by every four trees. In mixed orchards, where longer-lived trees are set out with a large spacing the quincunx system is useful, in that it permits the shorter-lived trees to be planted in the centre of the squares made by the other trees. The central trees are removed when the latter attain full size. The central trees are called fillers, due to which the quincunx system is sometimes also known as the filler system.

The third method is the hexagonal or septuple. In this the trees are equi-distant from each other ; six trees enclosing a seventh one, so that a line drawn through the encompassing trees makes a hexagon. Since seven trees enter into the figure, the name septuple is applied also to it. It is a difficult method to adopt, and is seldom seen in South India.

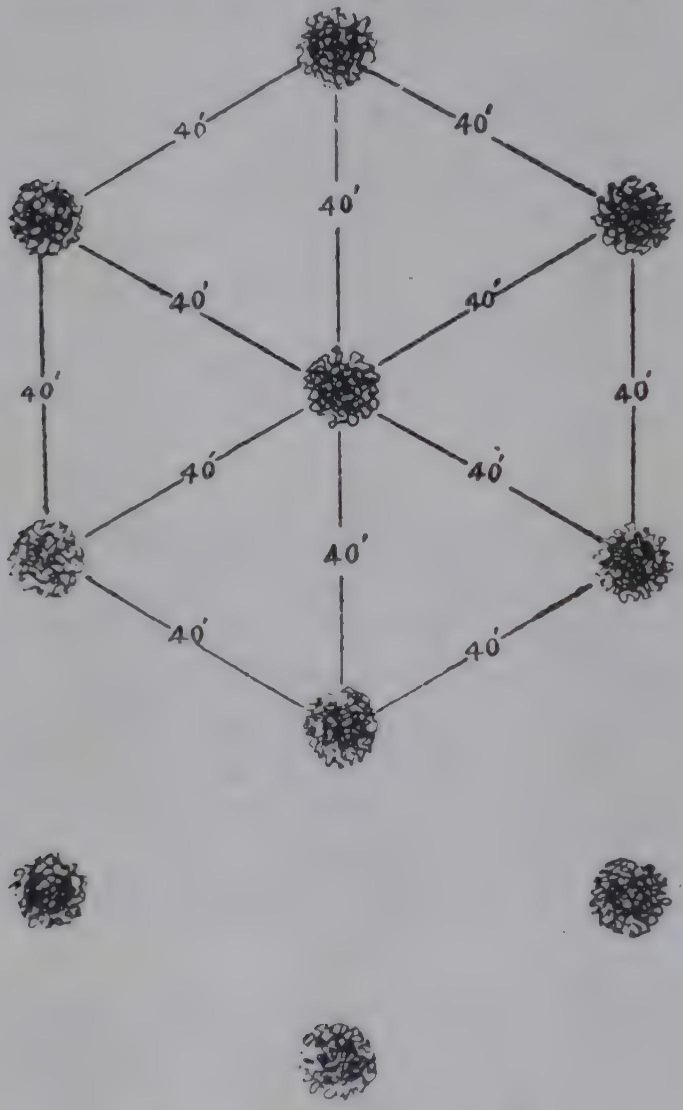


Fig. 20. Hexagonal system.

The following statement gives an idea of the number of trees per acre by the three systems of planting mentioned above.

TABLE 1. NUMBER OF TREES PER ACRE

Spacing	Square	Quincunx	Hexagonal
10 feet	435	870	500
16 ,,	170	340	195
20 ,,	109	218	125
24 ,,	75	150	86
28 ,,	56	112	64
36 ,,	34	68	39
40 ,,	27	54	31

On undulating ground or on the slopes of hills, the aforesaid methods of planting cannot be adopted. The fruit trees have either to be planted there on terraces or along the contours. Since the terraces are to be formed and contours have to be followed according to the nature of the slope or terrain, a standard system of planting becomes impossible. The arrangement of trees has to conform to the peculiarities of the site, keeping in view the aesthetic considerations and the more vital considerations of preventing soil erosion.

The terracing of slopes is an expensive operation and can be practised only in small areas. The object of terracing is not merely to provide for ease in orchard culture but also to prevent soil washing. Where terracing is not found feasible, the slopes should be left uncultivated in large strips between the tree basins and positions, to avoid soil washing. In contour planting, the tree rows are established along grade contours. This method is specially suited to shallow soils on rolling topography, where shifting of soils by terracing might expose the rocky or poorer sub-soils. The spacing of the trees may be uniform along a grade contour, or uneven with straight cross rows. Or again the trees may be planted on varying grades with straight cross rows. A regular plan for such contour planting cannot be prepared in advance, and the tree positions are therefore best decided on the spot.

HEDGES AND WIND-BREAKS

Hedges of some thorny type are common in most orchards in South India, and these are raised primarily as a means of protection from pilfering by human beings and trespass by cattle. The wind-breaks on the other hand, are generally but incorrectly deemed a luxury in South India. Like the hedges, these too are real assets to an orchard, since well-established live-hedge and wind-break belts serve to deflect the wind currents, and reduce wind velocity and moisture evaporation from the orchard soil to an appreciable extent. Particularly in cyclone-infested localities, the value of effective wind-breaks can never be over-emphasised. Reduction in flower and fruit shedding and prevention of mechanical injury to the fruit or tree, are the clearest manifestations of the influences of wind-breaks in certain periods. The effects of wind-break belts, however, vary with their height and density as also with the topography. According to some, the sheltering effect of a wind-break of moderate density is felt for over a distance, which is from two to five times the height of the wind-break on the windward side and up to about 20 times on the leeward side. In general, double rows of quick-growing and drought-resistant trees planted with a close-spacing serve the purpose in most situations in South India. Both the live-hedge and wind-break belts are best established prior to the planting of fruit trees. For the former, *Inga dulce*. *Prosopis juliflora* and agave (*Agave sisalana* and *A. mexicana*) are common on the South Indian plains. Pomegranate, tamarind, *Thevetia*. *Opuntia*. *Euphorbia*. *Casuarina equisetifolia* and cactus hedges have also been used in some parts. The plants used in wind-break belts are very much more varied and include scores of species. The selection should be confined to the very hardy trees, which are quick-growing and have a fairly erect habit, all the huge spreading types like tamarind, seedling mango, *Ficus sp.* etc., being excluded. In the Ceded Districts, the red sanders (*Pterocarpus santalinus*), *Millingtonia hortensis* and *Erythrina indica* are typical examples of trees found suitable for wind-breaks, while in sandy coastal areas *Casuarina* *equisetifolia* is popular. All these require to be planted very close with a spacing of about 10 feet only or even less. The cashew is also found to form an effective wind-break, because of its tendency to form practically an unbroken screen with its dense top-growth.

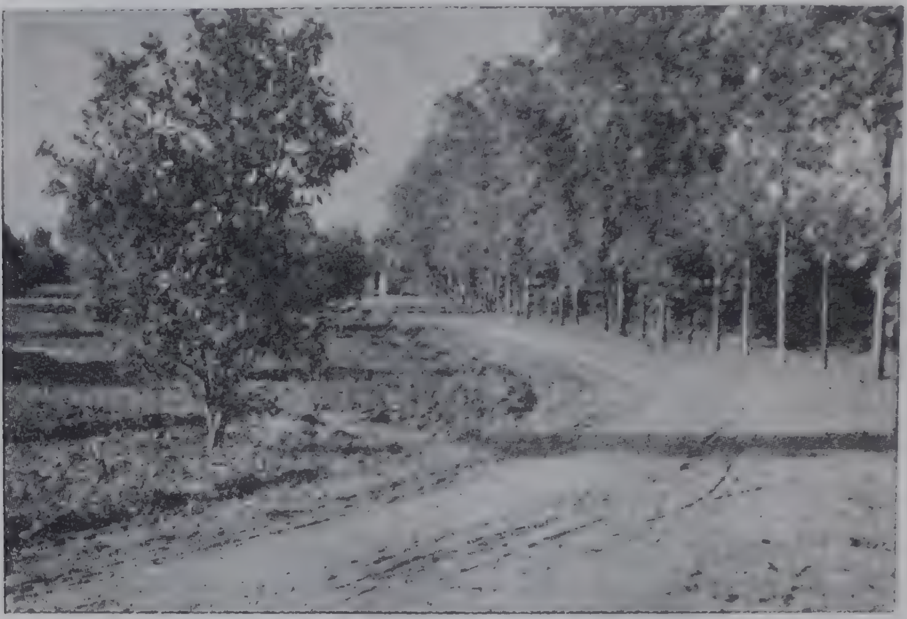


Fig. 21. Red sanders in the wind-break belt.

Roads and drains :—It has already been indicated that roads and paths are necessary not only for the beauty of the orchard but also for economic transport of farm produce, implements, manure etc. Some ingenuity and thought are required in laying out the roads and drains, so as to prevent the use of land for these at the expense of fruit trees. Too many roads and paths are as much a waste as too little would be found to be a false economy. The open drains should be made to run in straight lines and without interfering with the main roads. Such drains should also be as few as possible, since their cleaning is an expensive item.

Digging holes for fruit trees:—A tree setting plank of two to three feet long, with a notch in the centre and two notches on either ends, is found handy in the layout of an orchard. This plank is placed on the ground, with the peg previously placed in the orchard to indicate the tree position in the central notch of the plank. Two more pegs are then set on either side of the plank in the notches at the ends, and the central peg is then removed. When this is done, the digging of hole within the space marked by the pegs, may be commenced. Subsequently at the time of planting the trees, the plank is again brought into use. When it is placed on the ground with the two pegs at the ends in position, the tree can be brought to the central notch of the plank and planted there. This enables the tree to be set out exactly in the place marked for it at the time of layout. Without the use of the plank, the workmen will have no effective guidance, and may dig holes of varying sizes and shapes, in which the exact tree position cannot be easily detected later.

The digging of the holes is done preferably a few days after the rains, when the digging tools can be used with greater ease and effect. There is some controversy on the optimum size of the hole to be dug for fruit trees. When the soil is of uniform texture and good depth, large holes are unnecessary, and it will be a waste to dig such holes. A hole 2 ft. x 2 ft. x 2 ft. may suffice to accommodate the root system of the tree and to enable the soil to be thrown in all around the roots and to press the soil down evenly without damaging the roots or the ball of earth around the roots. In soils, where rocky and hard sub-soil layers are suspected, larger holes would be necessary, so that such uncongenial locations may be avoided. The pits after being dug out may be refilled and

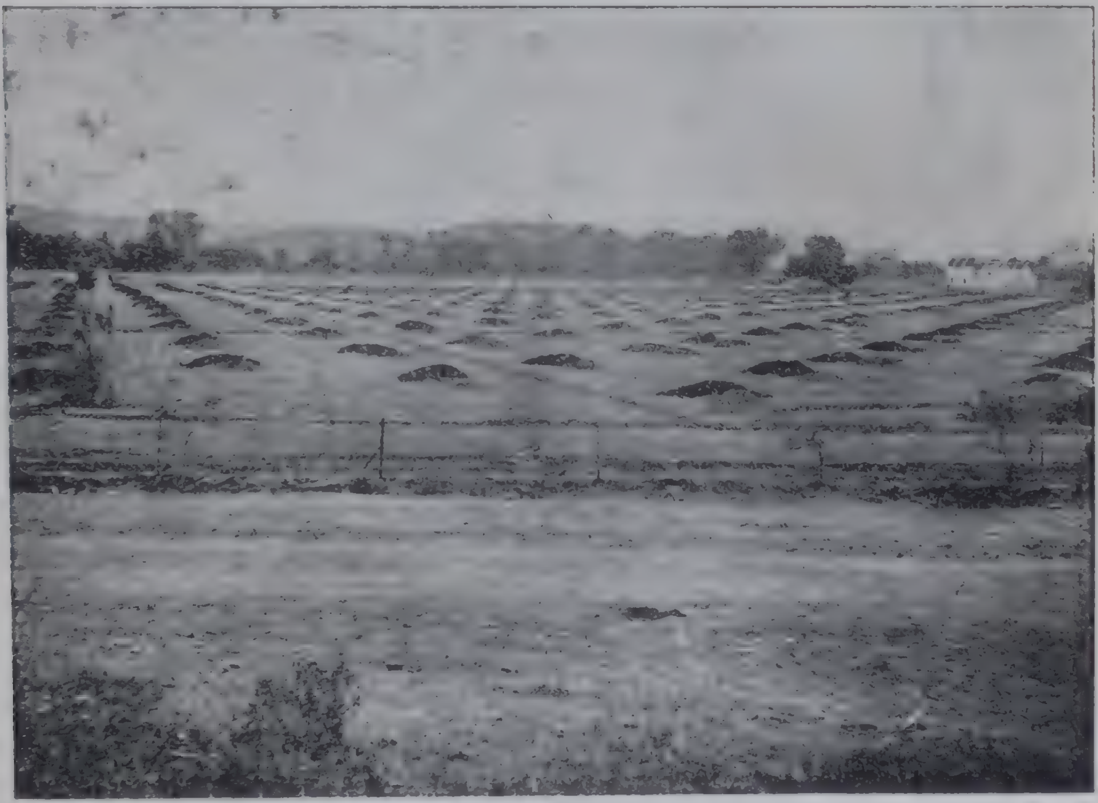


Fig. 22. Holes dug for a new orchard.

watered once before planting. This will tend to settle the soil down inside the pit evenly.

In the course of digging the hole, the advice commonly given is to throw the surface soil on one side and the sub-soil on another side, so that at the time of planting the former may be thrown in first and the latter on the top. This advice ignores the fact that the tree has to live on the same site for a long period of years, and its feeding zone is not confined to the area within the hole. The widespread practice of adding manure to the hole just before or at the time of planting the tree is to be deprecated, not only on the above ground but also because of the fact that the manure at the time of decomposition in the soil may prove injurious to the cut roots and may also attract white ant attack.

Planting distance :—It is fortunate that close planting is less common in South Indian orchards than in the rest of the country. There is, however, a great deal of scope for improvement. When trees are planted too close to each other, their roots become crowded, and this leads to under-nourishment of the trees. In periods of drought the closely spaced trees suffer more than properly spaced trees. Because of the lack of full scope for growth and development, the trees yield small crops. Inadequacy of light in thickly planted orchards also results in poor development of fruit colour on the lower regions of the trees. The cultural practices of the orchard are also hindered. The optimum spacing depends on the size of the full-grown tree in its full bearing age. The tree size in its turn is governed by soil, climate, variety and rootstock. Adequate spacing can therefore be only determined by a study of the tree growth in each tract. On this basis the range of spacing that seems suitable or is widely adopted under South Indian conditions for each fruit will be given in Part II.

Selection of trees and varieties :—Utmost care is necessary in choosing the varieties as well as kinds of fruits for an orchard, for on this depends the future profits or losses to as great an extent as on any other single operation. The safest procedure is to choose those varieties which have proved to have been adapted to the locality and fancied by the market. Novelties, however alluring they may be in the nurseryman's catalogue, have no place in a commercial orchard, and are best left out.

The tendency to stock too many varieties in a commercial orchard is to be deprecated. All varieties have their own peculiarities in respect of yielding capacity and fruit quality, and the selection must be confined to one of the very few best ones. More varieties can only be justified when they are required to help fruit set in the selected commercial varieties by supplying pollen.

It is always a golden rule for each grower to himself raise the plants required by him, but this is not feasible in most cases. The next best alternative is to obtain the plants from a nurseryman, who enjoys a good reputation for standard nursery stocks and for straight dealing. It is an advantage if the nursery is near, so that the purchaser may visit the nursery and select the plants himself. The nurseryman will be inclined to take all care to raise plants from the best mother trees if the customers show their awareness to the importance of proper selection of plants. Claims made in catalogues may be true or fanciful. They cannot be a substitute for adequate proof. The fact that the inferior fruit quality and poor or uncertain crop yields in majority of South Indian orchards are now known to be due to indiscriminate purchase and planting of trees, is an evidence that the public do not still appreciate the importance of the subject of plant selection. The plants should not only be of good parentage and on the right rootstocks, but also be free from any serious disease or pest, and further possess a healthy bark and fairly robust and vigorous look, as distinct from the sappy and tender growth which is often forced by heavy feeding and irrigation in the nurseries. The size of the plant is less important than the presence of well matured wood. A medium-sized plant with healthy and normal growth with well placed branches or shoots all around the trunk is to be preferred over the rest. The roots should be free from knots and should have sufficient lateral and fibre roots.

CLASSIFICATION AND NOMENCLATURE

The importance of a simple and widely accepted system of classification and a codified nomenclature, such as would enable the identification of fruit varieties in nursery and orchard, is now well recognised in all parts of the world. Classification deals with the grouping of fruit varieties according to their natural relationship, while nomenclature deals with the naming of varieties according to certain well accepted standards. Arbitrary methods of nomenclature and classification lead to confusion and have resulted in extensive plantings in the past of fruits not actually desired by the orchard owners. At present nomenclature in South India, as in the rest of the country, is more a matter of personal judgment. The ease with which new varieties spring up in Nature and the craze for coining new names, together with the commonly followed deceptive methods of cataloguing and description of varieties by some nurserymen, have all served to cause a great deal of confusion, which can only be prevented by the formation of a National Committee to codify names and evolve simple rules for nomenclature. Till then the growers and nurserymen can help by coining no new names, and not substituting a name to a variety already known by another name. In Part II of the book, the classification of the leading South Indian fruits is given in so far as it is evolved, along with the extant nomenclature. It has to be remembered, however, that since any classification is but a picture of the varieties at a given time, it is only a temporary arrangement of groups and individuals according to the available knowledge. When more is known about the groups and individuals, the classification has to be remade.

Systematic pomology is not to be confused with systematic botany. The latter aims to place varieties under species, species under genera and genera under families, while the former deals with the grouping of varieties into classes and sub-classes. The methods of classification must therefore necessarily vary between the two. In the main, the pomological worker attaches greater importance to economic characters, such as would render the identification of varieties easy by the grower and nurseryman. Further, unlike the genus and species concepts of the botanist, which are based on certain processes in the line of evolution, a variety in pomology maintains its identity mainly under a method of vegetative propagation.

Variety testing is an important feature of pomological improvement. A practical grower, nurseryman, student and research worker in pomology have all to be variety-conscious. Everyone dealing with the sale of fruits or with fruit product manufacture have to be also variety-conscious. The study of varieties and ability to identify the important varieties become, therefore, a necessity for everyone who has anything to do with the broader phase of fruit culture and development.

Descriptions are the foundations and the frame-work of systematic pomology. In recording such descriptions, a standard terminology is essential. A standard terminology is yet to be evolved for all fruits, but an attempt has been made in the direction with reference to mango, and this is detailed in a separate publication.

Age of trees at planting :—There is a widespread belief that bigger the plant or older the tree at the time of planting, earlier the crop and better the tree performance. This is only partially true, at its best. Even if it be completely true, we have to reckon the high transportation cost and the greater casualties and damage in transit when larger plants are used for planting. Older plants also establish poorly and take long to revive. Experiments at Kodur with mango have disclosed that, within age-groups of three months' interval at the time of planting, no difference is observable in the orchard performance of the trees. On a consideration of all factors, it seems wise to plant fruit trees within a year of grafting or budding.

Lifting of plants:—The plants require to be taken out carefully from the nursery bed or pot, to obtain as much of branching roots and root-fibre as possible. With deciduous plants and with some trees like the mandarin in humid areas and in heavy rainy periods, the lifting of the plant can also be done safely with naked roots. Elsewhere and with other evergreen fruits, the plant should be lifted with a small ball of earth around the root system intact. All roots projecting out of the ball of earth or are so long that they have to crumple up in the planting hole, should be trimmed off clean with a sharp knife or secateur.

A useful device to lift out small plants from nursery beds is the nursery transplanter devised at Kodur. It also serves the additional purpose of making holes in nursery beds for transplanting small plants. It is easy to work only in open soils of good tilth, where it has proved significantly more economical than other commonly employed tools like *dokudupara* or pitting crowbar.

Care of plants till planting :—The roots after lifting should not be permitted to dry out; and for this reason the tree should be well covered with wet straw or moss and old sacks and well packed before despatching over long distances. It is not uncommon to find the plant consignments allowed to lie exposed to the sun on railway station platforms for several days. Such treatment as well as rough handling of the plant packages are damaging and may even take the life of the trees. In such instances the nurseryman can hardly be blamed for the failure of trees.

Where some delay is caused after the receipt of plants and before actual planting, it is better to "heel-in" the plants as soon as possible. To heel-in, a trench may be dug or a deep furrow may be opened out by a plough in light, moist, well-drained soil. The plants may be put singly side by side in the trench or furrow, removing all the packing material carefully from the roots, and laying the tops all one way. Some loose earth may then be thrown over the plant stems and roots. The soil so thrown should sift down well between the roots. This treatment ordinarily holds the plants in good condition for a fair length of time. The trees should be put in the trench on the slant and never upright. It is easier both to put them in that manner and to lift them out, without having to pull.

PLANTING

The important factor that influences the time of planting is the rainfall conditions of a tract. Where the rainfall is not heavy. the trees can be planted in the beginning of the monsoon, so that they can get the full benefit of the season's rainfall. Where the rainfall is very heavy, it is better to defer the planting till the end of the monsoon. Planting should be avoided, however, during hot and dry spells of weather. The trees should be planted out in the afternoons rather than in the mornings and in cloudy and humid days rather than in fierce sunshine and dry weather respectively, and also when growth is dormant rather than when growth is in the course of development or is very active.

The general points to be noted at the time of planting are:—

1. Scoop out only a small amount of soil in the centre of the covered pit to accommodate the ball of earth around the root of the tree or the naked root portion.

2. Just before planting, remove the packing material around the ball of earth. This applies to cases where heeling-in has not been resorted to, and the trees are to be planted soon after receiving them. See that in evergreen trees, the ball of earth remains intact.

3. Place the tree erect in the hole and see that the roots are in their natural position, and not crumpled or twisted.

4. After planting, press the soil around the ball of earth without injuring the ball of earth or without damaging the roots.

5. After levelling the surface soil, apply water immediately so as to soak thoroughly, but not to stagnate.

PLATE I. VIEW OF A MODERN MANGO GROVE
(Courtesy of Fruit Research Station, Kodur)

(To face page 72)

6. Do not bury the bud or graft-joints of the plants in the soil : plant at the same depth as in the pot or in the nursery bed.

7. Give a stake to the plant to prevent heavy swaying to and fro in windy days, and to prevent damage to bud or graft-joints.

List of References

1. Naik, K. C. & S. R. Gangolly—A Monograph on Classification and Nomenclature of South Indian Mangoes. (In Press.)
2. ,, Some Useful Orchard Equipments Devised at Kodur, Madras Agricultural Journal, March, 1940.
3. ,, Promising Fruits, The Villagers' Calendar & Guide, Madras, 1945.
4. ,, Plant Selection in Orchard Economics, The Gardener, Vol. I, No. 4, 1938.
5. ,, Hints on Planting of Fruit Trees, Madras Agri. Dept. Leaflet No. 118, 1943, Reprinted, 1947.
6. ,, Hints on Raising Fruit Gardens, Villagers' Calender & Guide, Madras, 1942.
7. ,, Purchase of Mango Grafts, Villagers' Calendar & Guide, Madras, 1943.
8. Wickson, E. J.—California Fruits and How to Grow them, Pacific Rural Press, San Francisco, 1926.

CHAPTER V

ORCHARD IRRIGATION

The South Indian fruits are either raised under irrigation or mainly under rain-fed conditions. In either case the trees require irrigation soon after planting and in many cases in the first one or two years in the orchard. It may also be necessary to apply water to trees even in rain-fed orchards in seasons of exceptionally severe drought. In the case of rain-fed groves, however, irrigation is not a big problem, since water is applied only when the trees are very young or where trees show themselves very occasionally to be in distress by their wilting foliage. For the rest of the commercially grown trees, irrigation is of special importance, and often accounts for the largest item in the orchard production cost. Carelessness in the irrigation of such orchards may adversely influence tree health, yield and fruit quality, causing avoidable loss. The irrigation methods in vogue in South India for such fruits has generally followed in the past certain arbitrary principles. It is usual for some growers to apply water as and when available or as convenient to them, rather than to meet the real tree requirements. Such a policy is fraught with disaster, and explains why several South Indian irrigated orchards produce irregular yields, often causing even deaths of trees. As in all cases of fruit growing, the infinite variety of conditions of soils, climate and fruit varieties, makes it impossible to suggest a uniform irrigation practice. It is only possible to lay down some broad principles for general guidance.

Importance :—It is recognised that rainfall is not within the control of man and, therefore, the production of fruits cannot be left to the caprices of the monsoon. The importance of artificial irrigation becomes therefore obvious, especially in certain areas and with certain fruits. In actual practice, and as already shown, watering charges form often the major item of fruit production costs in several irrigated fruits, which fact by itself justifies a study of the subject by the producer with all care. Water is a very important constituent of living tissues of all plants and in many, it is stated to form over 50 per cent. of the living tissues. It is also the solvent for all plant nutrients. Considerable loss of moisture occurs in the soil due to seepage, run-off, evaporation and transpiration, and losses have to be compensated artificially in many instances and in the most economic manner possible. In irrigated fruits, it is a common experience of the producers to find depressed growth and yield associated with the failure to secure the requisite amount of moisture, causing great loss even in a favourable season. It is known that a slight addition of moisture to the trees at critical periods often brings about material increases in the crop yield and appreciable changes in growth features. Timely application of water in optimum amounts has also been found sometimes to foster regularity of bearing, prevent fruit or flower shedding, improve fruit quality, check pathological symptoms as fruit splitting, chlorosis, die-back etc. Extreme cases of soil moisture deficiency in irrigated groves may bring about the collapse of trees, as it did happen in many sweet orange groves in the Ceded Districts in 1945, when the rains were in defect and water in many tanks and wells dried up, rendering artificial irrigation impossible even to sustain the life of the trees. The failure to ensure an adequate supply of moisture before the establishment of an orchard is, therefore, a very unwise risk for any grower to take.

DETERMINING FACTORS

Some of the important factors which govern or determine the moisture requirements of fruit trees may be briefly set forth as under.

(*a*) Irrespective of the soil and the fruit, irrigation is influenced by the rainfall and its distribution. In other words, similar soils under different atmospheric conditions require varying irrigation practices, depending upon not only the rainfall but also the atmospheric humidity and temperature. This is due to the fact that the rate of transpiration by the trees and the evaporation of moisture from the soil surface are greater in localities where the temperature and aridity are higher, which therefore influence the time of application and the amount of water to be applied. Mandarins in Wynad and Coorg can be grown under rain-fed conditions, but in the dry plains of the Ceded Districts irrigation is essential for this fruit. These facts are generally ignored by persons who seek advice on the optimum irrigation practices for a fruit, from those possessing experience of fruit production in regions enjoying entirely different environmental features.

(*b*) Under a given set of conditions of climate or rainfall, a light or sandy soil requires more frequent watering than a close-textured soil. Even so, shallow soils require more frequent applications of smaller amounts of water than deep soils. In heavy soils movement of water is restricted, while in open soils free percolation leads the soil to give up the water more readily. A soil with a large amount of colloidal material tends to swell when wetted, due to which the moisture movement is retarded and the soil aeration is reduced. Soils showing on testing the same water-holding capacity may therefore act in an entirely different manner when wetted.

(*c*) The situation and environment of the orchard also exert profound influences. Thick wind-break belts or well-wooded areas in the vicinity tend to reduce the soil moisture requirements in the same way as these will be increased in open or exposed situations.

(*d*) The growth habits and other inherent characteristics of the varieties and kinds of fruits being different, they differ in their moisture requirements and drought-resisting ability. The producer has to know therefore the differential needs of the fruits he desires to grow. For instance, while the mango does not normally require irrigation after about the second year of planting on the plains of South India, the sweet orange cannot grow and fruit well without frequent and timely irrigation all through its life. Even among the sweet oranges, some varieties by themselves or some on drought-resistant rootstocks can do with less irrigation than others under the same conditions. As a general rule, all xerophytes require less water than the mesophytes.

(*e*) By giving more space between trees, a larger foraging space for each tree is provided and more soil is therefore available to draw the moisture from. On the other hand, in closely spaced orchards competition for moisture is greater. The irrigation practices have to be tuned therefore to the system of planting also to an extent.

(*f*) Seepage and run-off of moisture are influenced by topography, cultural practices, methods of planting etc., and to that extent influence moisture availability to the trees.

(*g*) It is wellknown that with progressive acclimatisation, an introduced variety gradually adapts itself to a tract, becoming more and more hardened, and consequently better able to withstand soil moisture variations and deficiencies.

(*h*) When intercrops or filler trees are grown, these naturally necessitate increased applications of moisture to the soil. Irrigation in such orchards as well as in mixed plantations has therefore to be devised in a manner that would not conflict with the needs of the main fruit.

(*i*) The growth and performance of fruit trees are considerably influenced by the training and pruning methods, manuring and other orchard cultural practices. For instance, a cordon-trained plant demands less moisture than an unpruned or relatively less pruned tree. The effects of all such orchard practices are exerted severally and collectively on the soil moisture requirements of the trees.

(*j*) Air movement has also an influence on irrigation practices of a given orchard. In windy periods for instance, moisture is required in larger quantities and at lesser intervals than in calm weather.

In view of the multitude of factors and their complexity, the real test to determine the water requirements of fruit trees and plants is the actual test in the orchard. It is impossible to generalise from the observations of a few persons in one or more orchards and to lay down "rule of thumb" practices. Questions like "How much water should I apply, and when or at what intervals?" cannot be answered satisfactorily except by the grower himself on the basis of personal experience of his own trees, sites, aspects of growth and culture in his own orchards. The determination of wilting coefficient by the use of moisture equivalent centrifuge, which is supposed to indicate the moisture content of the soil when a plant becomes permanently wilted i.e., when it cannot regain its turgor when surrounded by a saturated atmosphere, does not afford a correct guide, as was at one time thought of. The suggestions often made in the past that a particular fruit requires so many acre-inches of water for a year, may be deemed as arbitrary and inapplicable even to that fruit within a region. The line between adequate and inadequate rainfall cannot be drawn with any definiteness at present. The extent of precipitation, which is often laid down as a standard for judging the irrigation requirements of a fruit, is illusory, since much of the rainfall may be worse than useless, and may even cause injury by bad distribution, while a little rain may be more beneficial in another season.

Time of application :—As in the matter of quantity of water, so in the time of application, definite advice is impossible owing to regional and seasonal variations, and variations in fruits and culture. It is only possible to say that, water must be adequate to the demands of the tree and must be applied when it is most needed, and that the grower must see to it that his policy and practices conform to the above objectives.

To put these more definitely :—

(1) apply water only when the first 12 inches of soil have gone dry, and

(2) apply as much water as would soak a greater part of the root area.

A rough soil test is helpful in determining when to apply irrigation. It must be remembered that excess of water in the soil is as injurious to the fruit trees as scarcity of it. At present the growers apply water indiscriminately to fruit trees without finding out if the trees really need any addition of moisture to the soil. A rough test to find out the necessity for irrigation in bearing plantations is to examine the soil up to 12 inches depth in half-a-dozen different places in the orchard. If the soil is found dry up to 12 inches depth, by mere crumbling of the soil in hand, application of water to the soil will be justified. If, on the other hand, the soil is found moist up to 12 inches depth, it will be unnecessary and may even be harmful to apply more water. This rough test is essential, as a superficial look over the surface soil is most often misleading and does not indicate the real tree requirements.

METHODS OF IRRIGATION

Flooding :—This is possible only on flat ground. It is feasible where water supply is ample. It is undoubtedly a wasteful method and is inferior to check system in regard to the economy of water. It also leads to rank and excessive weed growth and increased cost on weed destruction.

Check :—The check system is suitable where vertical percolation in the soil is rapid such as in coarse or porous soils. It demands much soil shifting to form bunds which are put up to form square or rectangular beds enclosing one or more trees. These beds are generally of uniform size, level inside, and connected together by irrigation channels at the rate of one channel for every two rows of beds. This system is largely in vogue in Sathgudi and Batavian orange plantations in South India. Ample water is needed as in flood system with even more labour cost on making beds and bunds. Grove culture is rendered more difficult and expensive. In fine retentive loams, this system has been abandoned in other countries in favour of furrow system. By allowing water to sink away upon finely pulverised soil, puddling of the soil results as in flood system, and this has an adverse effect on soil texture. It is however more economical than flooding. Further, one is also certain by this system that each tree gets its full quota of moisture.

Basin :—The basins are small enclosures which cover only a limited area around each tree. This system is based generally on the misconception that only the immediate vicinity of the trunk is the main feeding zone. It is now known that the root zone spreads far beyond the tree spread. Restriction of the root or feeding area is therefore undesirable. As a result, small basined trees suffer more from adverse conditions.

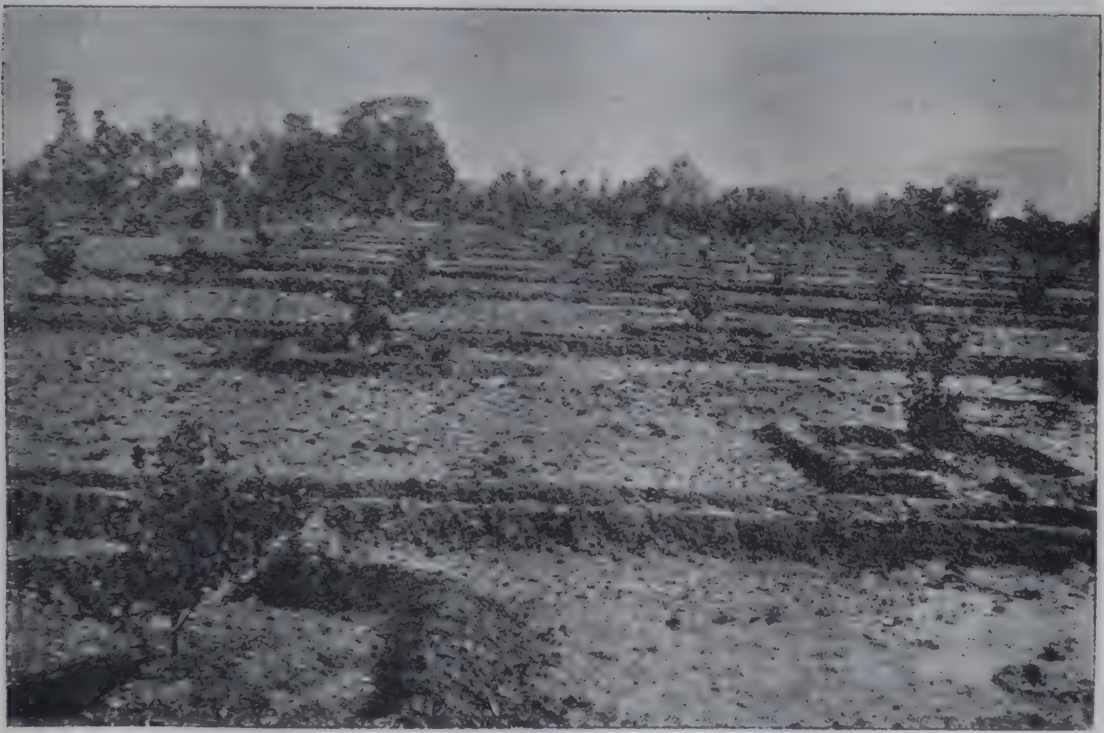


Fig. 23. Basin system of irrigation.

The system is, however, recommended on light sandy soils and in groves which are very irregular in slope or are on a steep gradient. In very sandy soils, furrow irrigation is impossible as the water penetrates too rapidly with the result that at the heads of the furrows the penetration is far too great before water can reach the lower ends of the furrows. Furrows are also not possible on irregular slopes.

Basins of small size are sufficient for young trees, but the size should be gradually increased as the trees age.

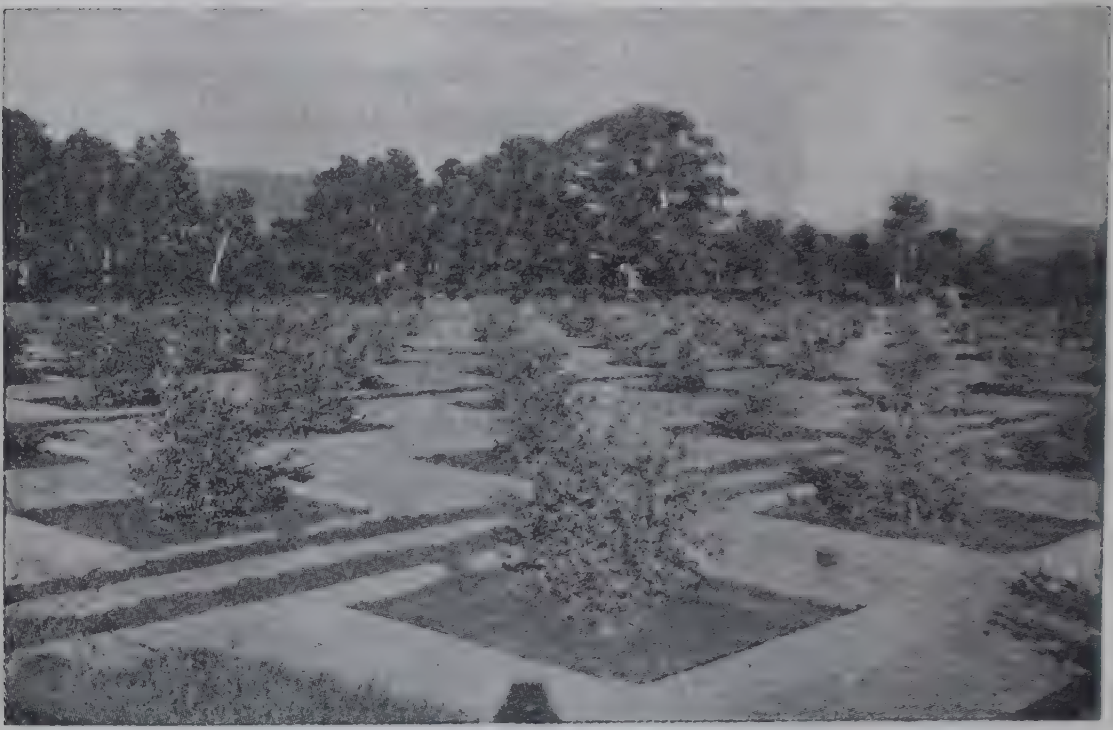


Fig. 24. Basins with one feeding channel for each tree row.

In areas where alkali deposits occur or where alkaline water has to be used, basin system is helpful, in that it gives deeper penetration than the furrow system and enables to wash the alkali salts down below the root zone.

Basin system is also useful when water is scarce, being more economical than the other systems referred to above in water use. Less of after cultivation and availability of more space for intercrops are other benefits. Cracking of the soil can be prevented in small basins by mulching and hoeing. Evaporation loss is also less as the basins are shaded by trees.

Basins are, however, of no value to old bearing trees, as they restrict the root system. On medium and heavy soils the system favours the development of root diseases. It may make harvesting difficult and may often lead to some damage to fruits from low-hanging branches.

Furrow Irrigation :—On medium and heavy soils this system has been recommended elsewhere. It prevents saturation of entire soil and thus reduces cultivation. There is no need to wait for soil to dry for inter-cultivation as in check and flood systems. It also leads to a saving of water, since loss by evaporation is little. The soil displacement is also less than in check and basin systems. It further favours even and deep distribution.

The above advantages are possible only with small and few furrows. In heavy soils a compact layer may be formed and this may prevent percolation, rendering sub-soiling necessary. Slow movement of water in furrows is also essential; else penetration may be uneven. Water also must stand for long periods in the furrows with the same objective.

The number of furrows between each row of trees varies with the tree size. With trees up to about three years of age, a single furrow on each side of the tree is ordinarily sufficient. Later the entire area of the grove may be covered by roots and the number of furrows may be increased up to seven. The furrow next to the tree row should be close to or under the drip of the branches.

On light soils the furrow should not exceed 200 to 300 feet. On heavy soils the run may not be over 400 feet. In longer furrows, much water is lost at the head of the furrows, accompanied by loss in soil fertility. In such cases the trees at lower ends do not also get sufficient water.

The use of shallow furrows is better than deep ones. It is common to incorporate fertilisers and manures in orchards in the upper six inches of the soil. When furrows are deep, the water moves in the upper six inches layer by lateral percolation and by upward movement. The result is a deposit in this shallow layer of soil of soluble plant food. Therefore this food is not easily available to the root zone. Even in the shallow furrows, water should be made to flow slowly to prevent erosion in light soils and to ensure satisfactory penetration in all soils. It is said that for good penetration, water should be run in each furrow for over 12 hours. The gradient of furrows should not exceed two per cent. (a fall of 2 feet in 100 feet), and should preferably be under one per cent. Furrow system has not been tried in South India and cannot therefore be recommended at the present stage with confidence.

PRECAUTIONS

With all fruit trees it is desirable to see that water does not stand in prolonged contact with the tree trunks, as this may lead to bark injury and foster gummosis in some fruits. The practice of forming a circular bund close to the tree trunk, with the alleged object of keeping off the irrigation water from the trunk has sometimes been advocated in South Indian orchards and has been designated as ring method of irrigation when combined with the basin system. In periods of heavy rains, water may be stored within this small ring and remain in contact with the trunk, thus defeating the very object of the grower. Sloping basins seem therefore preferable to the above system. The slope should be gentle and should permit water to stand up to about 4 inches depth in the basin at its periphery during every irrigation.

The growers should also take care not to run the irrigation channels on the exposed sides of the tree too close to the trunks. If done, the reflected sunshine in severe summer months may cause sun-burn on the trunks of the trees. The channels should be formed on the shady sides of the trees and kept as far away from the tree trunks as possible.

Careful destruction of weeds is an important means of effecting irrigation water economy. Improvement of drainage to remove surplus water from the soil is also an essential part of intelligent orchard management programme.

The tendency of irrigating orchards according to a set programme is too widespread a defect in South India to be passed without comment. Such blind adherence to a schedule has caused immense loss to orchard crop yields and even trees. The rough soil test mentioned in the foregoing pages should be invariably done before every application of water, if the water is to be given in due regard to the actual needs of the trees.

Much loss has also resulted in some orchards by the application of water suspected of alkali salts. The presence of certain salts in excess may prevent the plant from obtaining the normal supply of water and from absorbing certain nutrients. The extent of tree injury from the alkaline salt-containing water varies with the particular salt, with the rainfall and its intensity, with the type of soil and its drainage, with the quantity of irrigation water used and the manner of its application, and to an extent on the variety and kind of fruit. Water containing up to 700 parts per million of some of the sulphates has been termed as safe, if the soil is well-drained. Chlorides are said to be more injurious than the sulphates, while the carbonates are reputed to be the most injurious of all the salts. Apart from these, salts of sodium, potassium, magnesium and boron in excessive quantities, may also occur in irrigation to be toxic. In general, it has been stated that, irrigation water containing more than 750 parts per million of total soluble salts, unless a large part of these salts is in the form of calcium salts, should be treated with suspicion. Well water is usually more likely to be unsafe in this respect than the river water. In all cases of such doubt, the water should be got analysed chemically and expert opinion obtained before the orchard is planted. If the use of alkaline water is inevitable, a possible means of reducing injury is to apply such water at long intervals, securing deep penetration with each application.

RELATION TO CULTURE

The water absorbing power of heavy soils is considerably influenced by the method of tillage. Such soils should not be stirred while they are wet. Frequent shallow cultivation of such soils packs the soil immediately below the cultivated area forming plough-sole, which retards the movement of soil moisture. Improper soil cultivation makes the stiff soils compacted, fissured and cloddy. The soil moisture is lost rapidly in them by weed growth. Such imperfectly cultured soils settle around the tree roots like cement, tearing them off during subsequent shrinkage. They contrast badly with the irrigated soils amply supplied with organic matter and cultivated at the proper time. These latter soils are mellow, free and invite fullest activity of the tree at its roots. These soils therefore meet the tree demand for air, water and free soil condition. All these conditions however are dependent on proper irrigation and cultivation.

When the water table is away from the soil surface, as it should be in orchards, the combined downward pull can be greater than the upward pull. The upward movement of water by capillarity, it is now known, has been over-emphasised in the past. Frequent cultivation had been recommended in the past to break the capillarity and to reduce the loss of water from the soil through transpiration by plant life. It is now recognised that evaporation from a soil is virtually the same whether the soil is cultivated or not. This may lead one to think that cultivation is not essential for the purpose of soil moisture conservation. There is no doubt that the main source of water loss from a soil is through transpiration by plant life in it, but it is equally evident that cultivation of such a soil does not check losses that occur through evaporation.

Therefore, cultivation is beneficial in so far as it furthers :—

(1) the preparation of seed bed or orchard site or orchard soil for green manuring ;

(2) the incorporation of fertilisers or manures;

(3) the preparation of soil to receive moisture; and

(4) the destruction of weeds which rob the soil of moisture, and of pests and diseases.

Under tropical conditions and in heavy rainfall regions as in Wynad or hill slopes, where rainfall distribution is good, cultivation of entire groves is not necessary. This is because of the fact that the soil there has sufficient moisture supply; and also that a bare soil would greatly suffer from erosion during heavy rains. Further, large proportions of roots under such conditions are found in the upper six to nine inches of soil, and therefore, would be liable to be injured due to culture tools. Continual cultivation in all orchards also leads to the destruction of the organic content of the soil and a reduction of the bacterial life of the soil, the food supply of which is chiefly organic matter. They render essential plant food elements available to plant life.

Since one of the chief sources of water loss is through transpiration of weeds, it is important that the weeds are destroyed during the dry season in order that the moisture in soil may be conserved solely for the use of the trees. Thus, soil culture for weed destruction during the dry season is essential. But cultivation of a bare soil during the dry season, if no weeds are present, is unnecessary. Injury to roots in a dry season would also increase tree distress owing to moisture scarcity.

Irrigation channels or furrows have to be broken up after a few irrigations, as they tend to silt up and penetration and movement of moisture will therefore become difficult.

List of References

1. Chandler, W. H.—Fruit Growing, Houghton Mifflin Company, New York, 1925.
2. Gardner, V. R., F. C. Bradford and H. D. Hooker—Fundamentals of Fruit Production, McGraw Hill Book Co., New York, 1922.
3. Naik, K. C.—Brief Hints on Irrigating Fruit Gardens, Villagers' Calendar & Guide, 1943.
4. Wickson, E. J.—California Fruits and How to Grow Them, Pacific Rural Press, San Francisco, 1926.

CHAPTER VI

MANURING OF FRUITS.

Unlike agricultural or seasonal crops, fruit trees live long and possess large root systems. Their demands for plant food are therefore somewhat different. Fruits differ in not only feeding power but in the degree of tolerance to some elements and salts. The soil too varies in texture and in its plant food content as well as in microflora. The effects of rainfall, humidity, light and temperature are also varying on different soils and crops. Many of the hardy fruits are known to also produce satisfactory yields without any manuring, as for example the mango in majority of South Indian orchards, while in most fruits the response to manuring is less spectacular than in seasonal or agricultural crops. These various features together with the differing age, varieties and rootstocks, make it impossible to suggest a definite manurial programme, such as would apply to all the diverse conditions and fruit crops of South India. One has therefore to act largely on the probability, on the basis of available knowledge and of grove experience.

SOIL AND PLANT ANALYSES

The widespread belief that analysis of soil or plant is necessary to determine the manurial requirements is only true to a partial extent. Chemical analyses of soil do not take into account the loss of plant food by leaching, oxidation caused by orchard cultural practices, effect due to the action of soil micro-organisms, the physical and chemical effects of organic matter in the soil, and the continual changes in plant food from the unavailable to the available form. Such analyses therefore do not show the amounts of each element that the tree can absorb or the amounts that the soil should possess. They are, however, of value when one or more essential elements are absent or nearly absent and also in showing the presence of injurious salts or of salts in toxic concentrations. It is for instance, wellknown that the manurial needs of an alkaline soil are different from that of an acid soil, and that irrigation water containing salts above a limit is harmful. It is also known that soils highly acidic (below pH4) or highly alkaline (above pH9) are unsuited to most fruits. Analyses of soil or water therefore help in a limited manner and can be no effective guide to the manurial programme of an orchard.

Plant analysis as a means of judging the manurial requirements is yet an inexact science. Such analyses are in general defective guides, in that the quantities of elements removed by a crop are found to be much less than what the soil possesses, and yet it is found that applications of manures or fertilizers are essential to secure good yields in those soils.

It is true that all the elements present in a soil may not be in an available form to the plant. The term available means that the substance is soluble in the soil moisture and is so balanced with other constituents of the soil solution as to be assimilable by the plant. Further, the elements should be in a concentration at which they are not harmful or poisonous to the plant.

It is possible that a manure or fertilizer when added to the soil, may act contrary to expectations even though it may dissolve in soil moisture. The salt after dissolving may react with other elements or salts, producing a new soluble or a new insoluble substance. It is therefore to be expected that the application of a soluble fertilizer salt need not necessarily result in the increased availability of that salt. On the other hand, it may mean no increase of that substance at all in so far as the plant is concerned, but it may enrich the soil with respect to another element that was previously insoluble. Thus, increased soluble potassium in the soil is known to result, not merely by potash fertilizer applications but also by others which do not contain potash, but which set the potash free from its combinations with the insoluble soil minerals.

Recent work in several countries has brought out the importance of the reaction of elements in the soil in relation to tree performance. Thus, iron and manganese deficiency has been reported to be common in soils containing much lime, or are alkaline. Zinc deficiency is found also to be increased by phosphate concentrations. Ample organic matter in the soil may change the insoluble phosphates to a form available to the trees and may also react similarly with iron. Boron is stated to be more valuable in acid than in alkaline soils. In slightly alkaline soils (around pH8) zinc is precipitated and is held out of the soil solution, becoming useless to the plant. All these serve to make clear how complex are the manurial problems of a perennial crop like the fruit. It is particularly so, because the grower often finds that even if his orchard contains the major elements and these are applied to the trees regularly, yet the trees may suffer due to deficiencies of certain elements. For instance, sweet orange groves in South India have for sometime past been exhibiting symptoms of zinc deficiencies ; yet the trees have often failed to respond to soil applications of zinc salts.

Essential elements :—The chemical elements which are essential for plant growth are said to be over a dozen in number. Some of these are derived from the solid portions of the soil, such as calcium, potassium, phosphorous, iron, sulphur etc. Some others are derived directly or indirectly from air, such as carbon, hydrogen, oxygen and nitrogen. All these need not necessarily be provided to the plant by the fruit grower. What he has to add to the soil are intended to supplement the supply already present, in order to promote the optimum growth and crop.

The plant foods most commonly leached in soils are nitrogen, phosphorous and potassium. These are therefore the elements commonly applied in manures and fertilizers. Fertilizers containing all these three elements are spoken of as complete fertilizers.

Local variations :—A deficiency in all the three of the above-stated essential elements is said to be more frequent in heavy rainfall and humid regions than in arid parts. Soils in arid regions are in general higher in total soluble matter than those in humid regions. This is explained by the fact that in the latter, the soils are subject to continuous leaching by heavy rains and thereby become depleted in the several elements. In some heavy rainfall areas, calcium deficiency has also been reported. The manurial needs of an alkaline soil are obviously different from that of an acid soil. Iron, zinc and manganese deficiencies have been shown to occur largely in alkaline soils. A fertilizer which tends to reduce the alkalinity is expected to have a beneficial effect in such soils, as an acid-reducing fertilizer will have in soils of low pH. In this connection, it has to be mentioned that plant secretions also tend to increase acidity of soil solutions.

Besides the knowledge of the soil reaction, that of the texture of the soil also is of help in basing the manurial programmes. On light sandy soils for instance, it is known that applications of nitrogen, phosphorous and potassium by themselves are insufficient to give good crops or to foster good growth, they being deficient in several other elements also. Such sandy soils may also become unduly acidic under certain manurial treatments, when they may make magnesium and copper unavailable to the plant. Basic slag, ground limestone and dolomite have been recommended to reduce acidity. In soils with high pH, on the other hand, lime application is harmful. In open or porous soils, copious irrigation or heavy rains may leach soluble salts, making such soils poorer, and sometimes also removing the excess of any injurious salts. When the soil is wet, alkalinity is raised, rendering some plant foods unavailable.

DETERMINATION OF REQUIREMENTS

The enormous soil variations which exist sometimes even within an orchard, as well as the variability in the health, bearing capacity and other inherent characteristics, make it difficult to determine the manurial requirements of a fruit by simple field trials. Variations between sites in an area are well recognised by growers, but few realise that even in a soil which seems uniform within the same orchard, there may exist considerable variability within a few feet. In the same orchard, it has been observed that even though the soil is deficient in an element, some trees with larger root systems are able to absorb sufficient amounts of that element from the larger area foraged by their roots. Similarly, some of the inherently high-yielding trees in an orchard may mask the response to a manure application, while others may react differently. It is therefore difficult to expect clear-cut results from a simple and straight-forward manurial trial. A few rough trials conducted here and there in the past do not possess the requisite cogency and utility, and the results therefrom can have no application to orchards other than where the trial was performed. Persons who suggest set rules without any guidance from well-conducted trials in regard to manuring, are therefore doing no effective service to the fruit growing public.

The foregoing does not mean that an intelligent grower has no means of estimating broadly the manurial needs of his trees. Firstly, he can find out by getting the soil analyses made by a chemist, whether it is acidic or alkaline, and what the degree of acidity or alkalinity is. He can also find out the analyses of the manures or fertilizers he wishes to try or apply. He can then layout a rough trial in a part or whole of his orchard to determine which of the manures or fertilizers give the best results at the lowest cost. The trial need not be elaborate. Only a couple of rows of trees may be allotted for each treatment, and the treatments may be limited to a few. The trial when once initiated should be carried out without any change for at least five years. Excepting the actual tree yields from under each treatment and an yearly note on the tree health and vigour, no other records are necessary to be maintained. At the end of about five years, the grower should be in a position to know which of the treatments tried by him was the best, both on the score of tree response and economy. Unless very marked differences are observed, there is no point in going in for a costly manurial or fertilizer treatment. At the present stage there is no more rational or practicable method of judging the manurial requirements than these simple trials conducted by the grower himself with his own trees.

In such trials the grower should know the fairly safe standard to be adopted in regard to the quantities of each manure or fertilizer to be applied. The following may serve as a rough guide.

1. Nitrate of soda	375	lbs.	per acre
2. Sulphate of ammonia	300	,,	,,
3. Super phosphate (single)	300	,,	,,
4. Sulphate of potash	300	,,	,,
5. Cattle manure or compost	25,000	,,	,,
6. Oil cake (groundnut)	4,000	,,	,,

Organic manure :—These are the residues of plants and excrements of animals. They are the chief source of soil nitrogen. They furnish the element carbon, which is the source of energy for certain bacteria, having the power of adding nitrogen from the air to the soil, and for other bacteria and fungi which are concerned in changing the plant foods in the soil from insoluble and unusable forms to usable ones. Organic manures also help in improving soil texture and soil aeration. Green manuring which comprises of raising a leguminous crop in the orchard with the sole purpose of being cut down for incorporating in the soil all or most parts of the plants above ground, is one form of adding organic manure to soil, while addition of cattle manure, compost, oil cakes and green leaf are the other different forms.

To be of use in the soil, organic matter must decay fairly rapidly. Such decay is only possible in the presence of ample soil moisture. In other words, much organic matter should never be applied under arid soil conditions. If done, it may lead to soil injury due to drying out of the soil and the use of moisture by the micro-organisms attacking the organic matter and thus setting up a competition with the trees. So whenever organic matter is applied, water should be let in in ample quantities and the soil brought to a good tilth soon.

Application :—The litter of cattle manure and the stubbles of green manures should be ploughed in and incorporated well with the soil, and this must be immediately followed by irrigation. More irrigation and tillage must follow, if necessary, to secure a mellow and friable soil free of stubbles, quickly. Other manures and fertilisers should be evenly broadcasted and incorporated by irrigation and shallow surface soil working. It is possible to apply some quickly soluble fertilisers with irrigation water itself.

Manure should never be applied in the pit at the time of planting. It is better to wait till the tree is established on its new site and has made one season's growth. If the soil is very poor it is better to manure six to twelve months before planting. The application of manure should be done in a manner as to cause no appreciable root injury. The applications may be made once a year when growth is least active, or before the blossoming season, or before the main growing season for the year starts. In open or sandy soils, more than one application may be found necessary in a year, to avoid or compensate for the leaching off of the plant food.

It is common to apply fertilizers and manures in the basin around the tree, where the feeding roots are largely concentrated. In full grown orchards, it would be best to apply from trunk to trunk, leaving a small space of one to two feet around the trunk unmanured. In young trees the area of application should extend at least three to four feet away from the branch spread.

Green manuring :—Apart from the enrichment of soil in humus content and fertility and improving the physical and bacteriological content of the soil, green manures as well as inter- and cover crops in orchards help in resisting soil erosion during heavy rainfall. If the green manure is a leguminous one, it also adds nitrogen to soil. It is not however wise to grow the same green manure year after year. They should be sown after the commencement of rainy season and should be turned under before the close of the rains, so that sufficient soil moisture is present to decompose the green material. If drought periods are expected green manure should not be raised, as it will rob the moisture required by the trees.

Some of the manurial practices and principles relative to specific fruit crops are reserved for a discussion in Part II.

List of References

1. Chapman, H. D. and W. P. Kelly—The Mineral Nutrition of Citrus. The Citrus Industry, Vol. I, University of California Press, 1946.
2. Chandler, W. H.—Fruit Growing, Houghton Mifflin and Company, New York, 1925.
3. Gardner, V. R., F. C. Bradford and H. D. Hooker, Jr.—Fundamentals of Fruit Production, McGraw Hill Book Co., New York, 1922.

CHAPTER VII

ORCHARD CULTURE AND INTERCROPPING

It has been mentioned previously that the orchard soils are cultivated to remove weeds, to facilitate subsequent operations such as irrigation, to incorporate manures and green manuring, to prepare the land for sowing of inter, cover or green manure crops, to facilitate the control of pests, and the absorption of water in the soil when tillage or other operations have produced previously an impervious soil condition. Soil culture also facilitates the circulation of air in the soil and provides adequate quantities of oxygen for nitrification—the process by which the nitrogen contained in the organic material is made available. That cultivation causes a soil mulch which conserves moisture, is an old belief, which is no longer held as valid. It is incorrect to expect that tillage would result in a saving of water, since the distribution of moisture in the soil is not influenced by it. Where the soil is occupied by tree roots, the soil aeration is also not increased to any large extent. The influence of orchard culture may therefore be deemed to be chiefly the destruction of weeds, in so far as its effect on tree growth and performance is concerned. The weed destruction would naturally lead to a saving in soil moisture and plant food supply.

Extent of culture :—Deep tillage has no place in fruit growing except before the establishment of the orchard. Such tillage causes injury to the roots, and is therefore to be avoided. At best its role in orchard is limited to the breaking of hard pan, which cannot arise in any case if the right soil has been chosen for the orchard and the same has been managed intelligently. Frequent stirring of the soil is also to be avoided in orchards, if that would tend to cause any injury to the tree roots. In citrus groves it has been noticed that the root rot disease commonly occurs in orchards where frequent root injury is caused.

Shallow and infrequent culture should therefore be the features of orchard management. In early stages, however, green manuring and raising of intercrops may demand periodic running of the plough. The destruction of weeds need not always be done by the plough. Shallow working of Planet Junior Hand Hoes or other hand tools in the tree basins or furrows may keep the weeds in check. At any rate, the tendency to use the plough frequently in the orchard with the sole object of maintaining the orchard clean all through the year, is not only useless but it is wasteful, and may even be injurious by accentuating soil washing, compacting the soil below the plough sole, restricting root activity, causing root injury and disposing the trees to diseases.

Culture on slopes :—Culture of the orchard soil on undulating or sloping land is specially harmful, if done in certain periods of the year. Growing of a permanent cover crop on such lands or planting of strips of grass or close growing crops between the narrow strips of clean-tilled rows of fruit trees on the contours are the usual practices which are aimed to catch the soil and to strain it from the run off. Mulching with crop residues, grass or soil improving leguminous crops are also devices to protect the soils on such lands during the rainy seasons. Such mulches prevent the baking of soil in hot spells, and also aid the growth of useful bacteria in the soil and thereby stimulate the growth of fruit trees. Heavily and regularly mulched areas are also said to increase the available potash and organic matter in the soil and have a stabilizing effect on soil temperature, which favours bacterial activity. Risks of fire and of harbouring pests are to be guarded against in mulched orchards. Against the latter, it is suggested that the mulch may be kept off three to four feet away

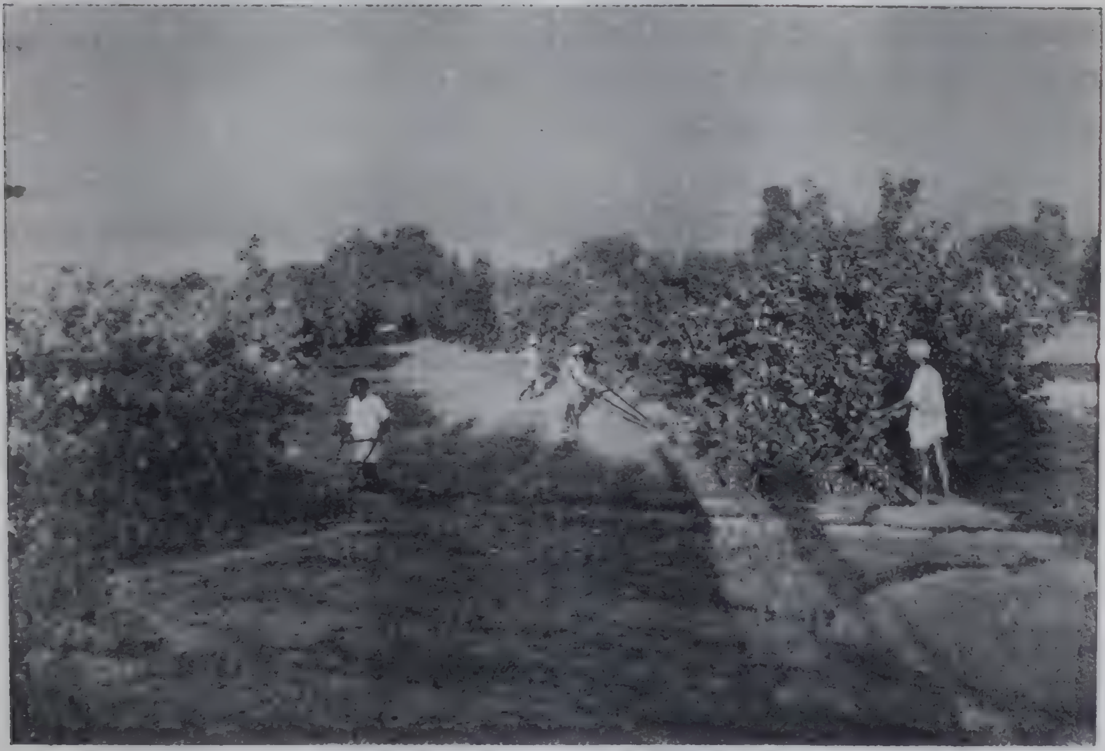


Fig. 25. Orchard Culture with Junior Hoes.

from the tree trunks. Intensive soil culture up and down the slopes is on the other hand, the best means of aggravating soil erosion.

Culture on level ground :—In a young orchard tillage need not be practised all over the orchard. It will be sufficient if it is restricted to the area covered by the roots, the rest of the space being reserved for inter or green manure crops. As the trees grow the cultivated area may extend till the whole alley space is covered in the full bearing age of the trees.

The commercial fruits of South India may broadly be classed under three groups in respect of soil culture. One is represented by the mango, which receives rarely more than one tillage a year after reaching the bearing age, and in which covercropping every year with ploughing of the alleys sometimes between October to January is the usual practice. The other is represented by citrus fruits, in which covercropping is never done in bearing groves, but frequent shallow weedings and ploughings once or twice a year are common. The third is the group of fruits represented by banana, in whose case only shallow weeding operations are possible after the plantation is established and space rarely exists for intercropping or using the plough.

From a consideration of the points mentioned above, it may be stated that normally the main ploughing or digging of the orchard soils may be done during the period when the trees are least active. In mango and citrus fruits, as in most other tree fruits, that period will be roughly from October to January. If the culture is efficient at this time, and if it is followed by shallow hoeing in other periods of the year, especially in irrigated basins or areas, weed growth can be kept in check. In the case of all weeds, they are best pulled out or destroyed before they seed. Planet Junior Hand Hoes are useful in cutting down the cost on shallow weeding operations, which are usually done by small hand-tools now in South India. All shallow weedings should be limited to only about three inches of upper soil layers, while the dormant deep tillage may be done up to six inches depth. For intercrops, the preparatory cultivation should be done when the soil is not wet, as culture of wet soils affect their texture adversely. The incorporation of green manures or stubbles of intercrops should also be done in semi-dry soils but during a rainy season, so as to have the aid of rains for the rapid decomposition of the organic matter.

Season for culture :—The time for grove culture depends on several factors. In rain-fed crops like the mango on the plains, one or two ploughings in October to December before the flush or blossom emergence may be useful to remove weed and check rank flush emergence at the expense of bloom. In irrigated crops also, culture at this period may be helpful to incorporate green manures and fertilizers. In other parts of the year, culture is only necessary to sow the cover, inter or green manure crops or to prevent weed growth.

Precautions :—In all culture with bullock power, injury to the trees by animals or ploughs has to be guarded against. It is common to provide with cages for the trees in the rows between which the tillage is done. Such cages may be of thin bamboo or of iron and can be easily shifted from row to row.

Other methods of weeding :—Besides mechanical weeding, weeding by the use of chemicals and more recently by certain growth regulating substances, has also been attempted. The former have never gained much popularity partly because of their corrosive or poisonous nature and partly due to the fact that few weeds could be destroyed by these means. Among the latter, 2—methyl —4 chlorophenoxyacetic acid (Methoxone and Agroxone being the trade names), and 2, 4— dichlorophenoxyacetic acid, more popularly known as 2—4 D (Weedone being a trade name), have assumed some importance. The efficiency of these for weed destruction depends on the correct timing of their application and rate of concentration. They are relatively inactive on monocotyledonous weeds as grasses and also on woody plants. Consequently emulsions or straight oils containing 2 —4 D have so far been used on a commercial scale only on monocotyledonous crops for destroying dicotyledonous weeds. Most fruit crops being dicotyledonous, are liable to be injured by these hormone weed killers.

Intercrops :—The growing of intercrops is done with the main object of adding to the income from orchard land, particularly in the pre-bearing stage. In irrigated groves such income is by no means insignificant. Tall growing intercrops are less favoured than short statured ones. Cereals of all kinds are grown, but in their case injury to trees may occur from the heat deflected from straw and stubble. Whatever the intercrops be, the grower should see that the requirements of intercrops are not at variance with the fruit trees. For example, to grow a crop of paddy or sugarcane with their enormous water requirements in an orange or mango orchard is unwise. The intercrops should also be not such that will exhaust the soil of moisture and plant food to the detriment of fruit trees. Shallow rooting vegetables as onions, melons, beans, carrots, tomatoes etc., are the best. Leguminous crops which have the capacity to add nitrogen to the soil are useful, especially if they are rotated with other intercrops. In such cases, addition of phosphatic and potash fertilizers are desirable to compensate for the loss of these by the growing of leguminous crops. In any case, the intercrop should be several feet away from the tree rows, so that the latter do not have the shade effect. Closely grown intercrops may accentuate disease by the humid and warmth associated with such close planting.

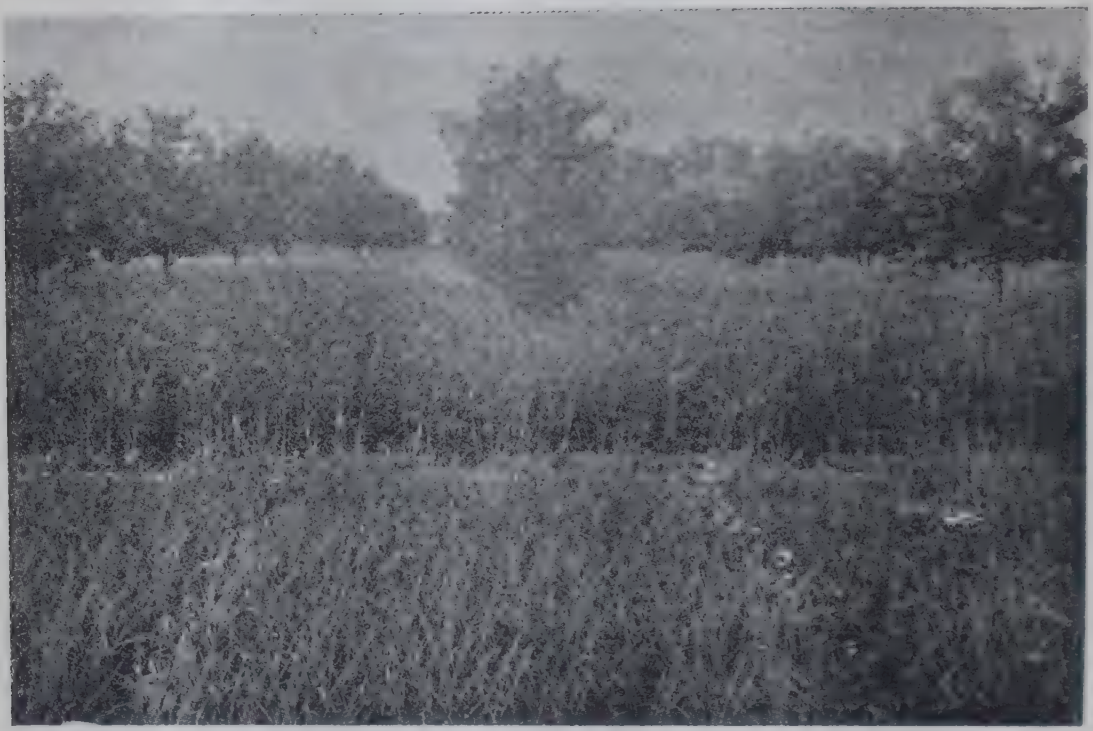


Fig. 26. A thickly sown intercrop rather too close to the trees.'

In very rich and deep soils and where irrigation facilities or rainfall are good or ample, intercrops of small fruits are possible for a number of years. Pineapple on the plains and strawberry on the hills are most suitable fruit intercrops. Some grow papayas or even bananas amidst tree fruit plantations.

All intercrops should be deemed as secondary crops. The demand made by them on the orchards should be compensated by adequate irrigation and manuring. As soon as the trees occupy the full space reserved for them on attaining their bearing age, the intercropping should cease, except for green manuring or covercropping.

Covercrops:—When a crop is raised not for green manuring, it is called a cover or intercrop. The covercrops prevent the declining soil fertility which would otherwise occur by soil erosion. Legumes are generally preferred as covercrops as they improve the soil chemically, besides physically and mechanically. They are specially valuable on sloping grounds. Sometimes a covercrop indicates spots which are lacking in soil fertility and requiring special attention, by the colour and vigour of the plants on such spots.

List of References

1. Chandler, W. H.—Fruit Growing, Houghton Mifflin Co., New York, 1925.
2. Gardner, V. R., F. C. Bradford and H. D. Hooker Jr.—Fundamentals of Fruit Production, McGraw Hill Book Co., New York, 1922.
3. Swarbrick, T.—Growth Regulating Substances in Horticulture, Part II, Journal of the Royal Horticultural Society, Vol. LXXII, Part 9, Sept., 1947.

CHAPTER VIII

TRAINING AND PRUNING

Principles :—To become a successful fruit grower, it is not enough if one secures plants of the best variety, plants them in the most suitable site, waters and feeds them well and in time. To secure healthy growth and good yields, the trees should also be trained and pruned properly. Unless the tree mechanism is built up in a particular way characteristic of the variety and unless the mechanism is made to function efficiently, much of the results of tree and varietal selection and of other orchard practices may be nullified. The building of the frame-work of the tree to the desired shape or form is effected by the operations that fall under the subject of training. Although the training of the tree involves some pruning, all pruning is not done for training the tree. Pruning as done mainly after the trees reach the bearing age, aims to maintain a balance between healthy and vigorous growth on one hand, and fruit production on the other. The pruning in fruit trees is not done for beauty, as in ornamental plants. The fruit trees are pruned essentially to secure good crop yields, consistent with the tree health and its age.

" Every body cuts but few prune " is a saying which emphasizes the need for careful and intelligent pruning, either for building the frame-work or for efficient production of fruit. Every fruit has its characteristic growth and bearing habits. For instance, some like the mango produce fruits mainly on the terminal shoots ; some varieties of apples on the other hand, produce fruits mainly on spurs, while still others like the jack produce fruits on the trunks or main limbs. A standard method of pruning may therefore result in crop restriction in some fruits, while it may foster and increase yields in others.

There is a tendency in some fruits to bear excess of crop, which may lower the quality of fruits in that season and may restrict the production of fruit in the succeeding season. In such cases, pruning helps to thin fruits in the heavy cropping year and improve fruit size and quality, and incidentally to foster regular bearing habit. It is also possible to regulate the bearing by distributing fruiting wood on all parts of the tree evenly, and prevent undue concentration of fruit in some parts. Careful pruning presupposes, therefore, an understanding of the bearing habit and growth peculiarities of every tree and variety.

The general principle involved in the training of fruit trees is the building up of a strong tree with branches placed on all sides of the tree, but sufficiently wide apart. When branches arise opposite each other or when the tree has only very narrow angled branches, the tree becomes structurally weak, forming what are known as very wide or weak crotches respectively. During high winds or in seasons of over-bearing, the trees with such crotches may be severely damaged by splitting or breaking off at the crotch.

It has to be remembered that pruning in general is a dwarfing process, depending upon the severity of the operation. This implies that a fast growing shoot or branch can be cut back more severely than a slow growing branch or shoot. Despite the fact that the net result of pruning is a decrease in tree size, careful and intelligent pruning may often lead to an effective increase in vigour of growth. This is explained by the fact that some branches when pruned give rise to a crop of lateral growths, which may produce eventually more wood and foliage than the portion actually removed. Excess of pruning may also limit the fruiting area and thus divert the plant energy and stored food material to the production of more vegetative growth. Many trees which have been subjected to pruning in early stages are known to reach bearing age later than unpruned trees, as a consequence of the above-stated feature. This also shows that in early age of the tree, more severe cutting is possible than at the age when the tree is in its bearing state.

It is a common feature in trees that an upright branch or shoot grows more rapidly than a horizontal branch or shoot. In the building up of the tree frame-work, therefore, the main branches and leader shoots should be trained to an erect or upright position. Among the secondary growths also, it has been noted that, shoots or branches originating directly one over the other and are growing in the same direction are undesirable, since in such cases, the upper shoot or branch has an advantage and is likely to shade and starve the lower one. This point has to be borne in mind while training young trees.

An efficient tree is an ideal combination of a few strong dominating limbs with numerous secondary growths. If too many main limbs are retained, none of them will be dominant. At a later stage when the superfluous limbs are cut, it only serves to produce a crop of secondaries at the cut places, without in any way strengthening the frame-work or improving the distribution of fruit wood. The object of the grower should therefore be to train the tree to the shape characteristic of the variety by minimum of pruning, but at the same time eliminating useless and superfluous growths, and fostering the development of selected leader shoots and limbs in a manner to secure strength of frame-work and evenly distributed fruiting wood.

Method of training :—Training of the tree is restricted largely to the pre-bearing age of the tree from the nursery or planting stage. The procedure in many deciduous fruits usually consists of heading back the young plant, selection of a few well placed scaffold limbs all around the trunk at proper distances from each other, and elimination of the rest, as well as a corrective pruning of the frame-work to foster a tree top of the required height and spread. Pursuant to these principles and depending upon the varietal peculiarities of growth and fruiting, three systems of training are recognised.

The first is the close-centred or leader system, in which only the main trunk is allowed to extend, forming many scaffold limbs on all sides. Such trees are upright, bushy topped and generally strong in frame-work.

The second is the open-centred or vase-shaped tree, in which the young plant is headed back to form several main limbs around the trunk, which spread out giving the characteristic tree top shape resembling that of a vase. According to this method of training, more sun light is received by the tree, and this is likely to be of help in producing better coloured fruit than in the leader or close-centred trees.

The third system is intermediate between the two described above and is known as the modified leader. In this, the plant is first trained to the leader system in the first few years, after which it is headed back to give the open-centred tree. It is believed to combine the advantages of the other two systems.

Training operations :—Whatever the system of training be, the grower has first to decide at what height from the ground level the scaffold limbs should be allowed to emerge. The height of the head, i.e., the distance from the base or ground level to the point of emergence of the scaffold limbs, varies between fruits and between regions or sites. Some growers fix this at the time of planting, while others may do so after some years. Low-headed trees are undesirable from the point of view of orchard culture, as the lower branches of such trees spread close to the ground, rendering the soil culture around the trunk and under the low branches difficult. In some trees the fruit may also be borne too close to the ground and may be subject to damage by irrigation water. All scaffold limbs lying at a height of less than about two feet from the ground make low-headed trees. Budding or grafting close to the root or planting the tree deep in the hole also leads to a similar condition. Since in some trees lower branches yield crops early, the growers often prefer to have low-headed trees in the first few years, and remove the lower branches at a later stage. Such severe pruning at one time is undesirable, in the same way as all forms of hard cutting back are in trees of all ages. At the same time a high-headed tree, especially when trained to close-centred form, is to be avoided, since in such cases the long exposed stems are liable to sun scald. Considering all the facts, it is suggested that most of the South Indian tree fruits are best trained to medium headed trees, with scaffold limbs arising at a height of not less than one foot from the trunk at a fairly wide angle to the main axis.

Having decided upon the height of the head, the next point to be considered is the number of scaffold limbs to be allowed around the trunk of the young tree. Few limbs if retained, may lead to wide crotch formation, while many may inhibit rapid growth of the tree. About half-a-dozen for a young tree are deemed to be the optimum number, and each of these requires to be chosen with care and should be distributed all around the stem.

With many fruit plants it is found that a proper selection of scaffold limbs is not possible at the time of planting. Each tree has therefore to be watched carefully in the first three or four years of its orchard life, and the frame-work has to be regulated during this period.

Sometimes the need arises for training the old trees in the orchard also. Trees that grow very tall may have to be kept within bounds or those that are deformed by some reason or other may have to be subjected to some treatment to correct the shape. Dehorning, i.e., severe cutting back of the main limbs, is a device adopted to achieve these ends ; while a less severe form is to frequently tip the growing shoots to an inner or outer bud for regulating the course of the future growths in the required direction. In all forms of training, it is to be remembered that, a part of the tree pruned more severely will produce more abundant and rapid growth than the part pruned lightly. To promote equal effect, therefore, the different parts of the tree should be cut back to an equal degree.

Pruning methods :—Since the bearing habits are characteristic for each variety or species, and the object of pruning is to modify the same to suit the grower's requirements of securing high yields of best quality and at a low cost, successful pruning presupposes a knowledge of the bearing habits of the trees to be dealt with. The methods of pruning of each fruit is therefore reserved for a discussion in Part II, to the extent possible. It may, however, be added here that all pruning is either heading back or thinning of growths. The former leads to more of new growths, while the latter is primarily intended to secure more of fruiting wood. In well-formed trees, the latter is therefore of greater importance than the former. Excessive or indiscriminate heading back may also result in production of tall and weakly formed water sprouts, which may have occasional value in filling up the blanks, but which otherwise are an evidence of defective pruning and orchard management.

Relation to nutrition :—It is established that both growth and reproduction in plants are associated with the nutritional condition. Thus, vegetative growth is favoured when there is an excess of nitrogen and there is scope for synthesis of carbohydrates. On the other hand, trees which are moderately vigorous, and in which the carbohydrate utilisation lags behind carbohydrate manufacture, tend to be fruitful. Pruning tends to influence both the accumulation and utilisation of carbohydrates, and the ratio between them. Heading back serves to remove large portion of the food reserves and incidentally fosters more vegetative growth.

Root pruning :—Regular pruning of roots in orchards is now known to be deleterious and to have a dwarfing influence. By inhibiting vegetative growth, it helps to divert the stored foods within the tree for the production of fruit buds. The balance between growth and production is thereby upset, and when performed regularly or severely, progressive decline in yields and even premature deaths occur. Trees root pruned in summer have been known to succumb all on a sudden. Excepting for the root pruning associated with orchard soil culture, which is inevitable, root pruning as a distinct orchard operation has no place in South India. It may however be useful as the last resort in orchards planted to very vigorous and shy bearing trees for securing higher yields.

Stripping, notching, ringing and girdling :—All these are operations, which are intended to sever the sieve tubes, which carry the food within the plant. As a result the passage of food below the wounds made by these operations, is prevented ; and thereby the carbohydrates are accumulated above the wounds, until the wounds heal. The slight decrease in nitrogen and the considerable increase in carbohydrates lead to fruit bud formation in the treated trees, if the treatments are performed at a time when the growth is active. But several fruits do not respond well to these, and some may even be harmed by the treatment. Even in the class of fruits which respond, only the vigorous and healthy trees should be subjected to these treatments. Weak trees have a high amount of carbohydrates but very little of nitrogen, and when these are treated by any of the

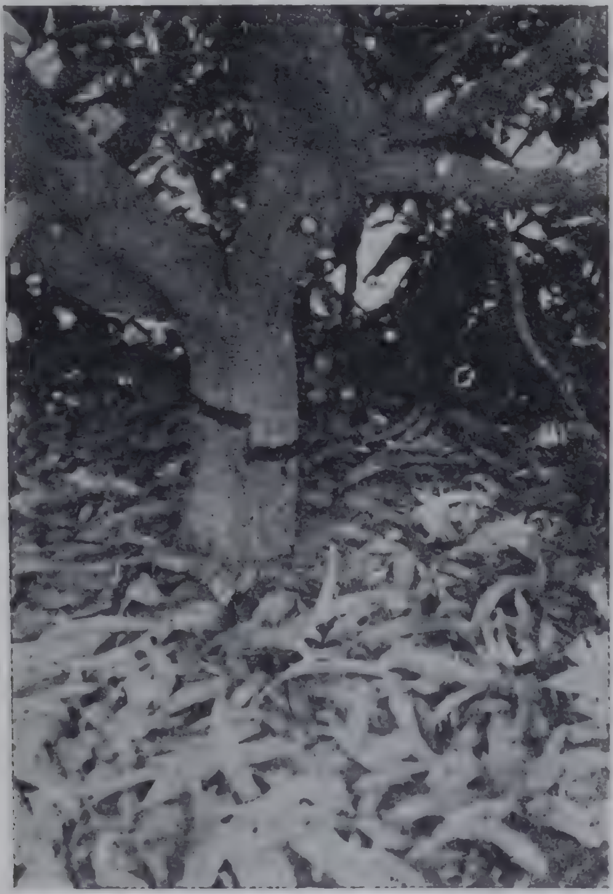


Fig. 27. Ringing of tree trunk

above methods, they cannot possibly respond, as the treatments only serve to aggravate the existing nutritional position. Quick healing of wounds is also important, if the treatments are to succeed ; and there are cases where long delays in healing have caused the deaths of trees by root starvation. Stripping of bark is rarely done in fruit trees, as it is a crude and severe form. Notching has been tried with figs, but never on a commercial scale. Girdling i.e., removal of bark all around the trunk or limbs in the form of large strips of bark, is also not an orchard practice, and is resorted to mainly for destroying an unwanted tree. Ringing, by removal of one-fourth to one-half inch wide bark strips or by merely scouring the trunk or limbs, either completely round or in the form of semi-circles in opposite directions at a spacing of two to four inches from each other, has been more commonly tried in orchards, to sever the sieve tubes of the phloem, and thus to increase fruit bud formation.

Thinning :—Thinning of flowers or fruit is done regularly with some fruits in temperate zones in order to obtain better fruit size or colour, but is seldom practised in South Indian orchards. The few attempts made in South India have shown that generally such operations tend to reduce the gross yields in all trees except those which tend to produce heavy crops. When thinning is done, the extent of the treatment is not to be judged for the tree as a whole but on the basis of the load which each branch is required to carry. This is because of the fact that all the branches do not crop in the same way and the fruits have therefore to be thinned dissimilarly. Thinning can only be recommended for heavy bearing trees, and only if the cost of thinning is compensated by better prices secured for higher grade fruits.

Deblossoming has sometimes been suggested to regulate fruit size in a season and to foster annual bearing tendencies. In most trees deblossoming is not feasible and is very expensive. Its value as a regular orchard operation is therefore dubious.

Smudging:—Like flower and fruit thinning, smudging is really an operation quite unconnected with pruning or training, but is nevertheless referred to in this place for the sake of convenience. The treatment consists of generating smoke under or near the trees, by burning of trash with some soil thrown over to check rapid combustion. The smoke and the heat so produced are claimed to induce the trees to throw out blossom, if the smudging is done sufficiently long. The treatment has never been done on an orchard scale in

South India; and certain trials conducted at Kodur have not produced any conclusive results.

List of References

1. Chandler, W. H.—Fruit Growing, Houghton Mifflin Company, New York, 1925.
2. Gardner, V. R., Bradford, F. C. and H. D. Hooker Jr.—Fundamentals of Fruit Production. McGraw Hill Book Co., New York, 1922.

CHAPTER IX

CROPPING

Given the right nutritive conditions, a bud may undergo differentiation and develop into a fruit bud. The bud differentiation may occur just before the emergence of blossoms or several months before. The fruit buds arise in definite positions, depending upon the characteristics of the variety or species. They may be produced terminally or laterally, on fresh growths or on older growths, on normal shoots or on spurs. A spur is a very short shoot, sometimes only a fraction of an inch in length, and often is quite distinct in structure and appearance from the other shoots, generally with short internodes, and capable of functioning for many years. Fruits are commonly classified according to the fruit bearing habit. Thus, mangoes which produce fruits on long terminal growths are representative of one class, apples and pears which fruit on spurs also are of another class, and jacks which fruit adventitiously from any point on the exposed bark or limbs are of the third class. It is also common to separate the fruits according to the structure and form of flowers and fruits, such as to designate apples and pears as pomes, and peaches andd plums as drupes. Still other methods of grouping are followed such as bush fruits for slow-statured crops like Cape gooseberry, brambles for fruits like blackberry which have a prickly form, tree fruits for tall growing fruits like the mango, citrus etc. Based on the structure of flowers, those which have flower buds containing flower parts only as mango, peach and plum fall in one class, those with mixed flower buds like apple, grape, fig etc., falling in another class.

Limiting factors :—The fruiting capacity of a tree is conditioned by a very large number of factors. The genetic features or the inherent characteristics of the plant are unquestionably the most important of these. The nutritional conditions, age of the tree, health and vigour, environmental influences, diseases and pests and orchard cultural practices are other factors which influence the fruit bud formation, fruit set or ultimate crop yields. Some of these are dealt with elsewhere in this book, but those relating to fruit set is touched upon in this chapter.

Fruit Set:—Among the inherent characters of trees which influence the yield, are also those which are reflected in the failure or success of the flowers to set crop with their own pollen. One of the prominent causes of crop failure in some orchards is due to sterility of various degrees. Trees are self-pollinated or self-fertilised, when pollen from the stamens are placed on the pistils of the same flower for fertilization. In clones or vegetatively propagated trees, the term self-pollination is used even when the pollen is transferred from the flower of a tree of one clonal strain on the pistil of another tree of the same strain. Thus, the Neelum mango is said to be self-fertilized whether the pollen is received from the same flower or from the flowers of another Neelum tree. If viable pollen is not available in abundance or is unable to fertilize the ovules, the result is a poor fruit set due to incompatibility. The poor set due to this factor should not be confused with the poor set as a result of defective pollination or pollen tube growth under uncongenial weather conditions, or defective nutrition, or disease and pest incidence.

The self-fruitful varieties can be safely planted in solid blocks, while the others require the aid of foreign pollen to give satisfactory yields. Provision for cross-pollination is usually made either by planting trees of the compatible varieties in the orchard or by top-working such varieties on a few limbs of the trees here and there. It is reported that even the normally self-fruitful varieties give increased yields as a stimulus of cross-pollination. Planting of two or more varieties of the same kind of fruit and which bloom at the same time, is therefore a safe procedure in the establishment of commercial orchards. In some fruits like the papaya, persimmon and date, it is necessary to plant one tree of the pollinating variety or type for every eight to ten trees in the orchard. The cross-pollination is aided effectively by insects in most fruits; and in this connection bees are the most useful agents. An apiary is likely to be beneficial in self-fruitful orchards also. With dates, the flowers are to be artificially pollinated by man in order to secure good yields.

Fruit shedding :—Those flowers which fail to get pollinated or fertilised become the "drops." Flower shedding occurs in all orchards, whether fully provided with compatible pollinating varieties or not. Since a tree normally produces many more flowers than it can carry to fruit maturity stage, a proportion of the flowers must shed naturally; and such shedding should cause no concern to the grower. But shedding of flowers as well as of fruits may sometimes be abnormal so as to severely restrict the yields. Such shedding may occur in several stages. The first of these is shortly after blossom emergence, and is largely due to the abortion of the pistil. The second is a few days later and may be due to defective or lack of fertilisation. The third is the shedding which occurs a few months later, owing to certain physiological factors. Other stages of shedding may occur due to mechanical or pathological causes as well as to some other internal and external causes, each of which is briefly touched below.

(*i*) *Sex-distribution* :—In some fruits the same tree does not possess the male and female organs. For instance, in monoecious plants like the melons, the staminate and pistillate flowers are on the same plant, while in dioecious plants as in most papayas and in date, the male and female flowers are produced in different trees. The monoecious plants are generally self-fruitful but the dioecious ones have to be interplanted in the orchard for securing good fruit set or have to be artificially pollinated. In yet another group, the inflorescence may have very few female flowers with a large preponderance of male flowers as in mangoes and cashew; and it is possible that even the few female flowers may not all secure suitable viable pollen. These features may bring about abnormal flower shedding.

(*ii*) *Heterostyle* :—Defective floral structure, such as short styles and long filaments in some flowers and long style and short filaments in other flowers, may lead to poor fruit set. Self-pollination is prevented in such cases, and flower shedding is the natural result.

(*iii*) *Dichogamy*:—Prevention of self-pollination may occur in perfect flowered plants by the maturing of the two sex elements at varying periods, such as the ripening of the stamens before the pistil or *vice versa.*

(*iv*) *Aborted organs* :—Degeneration of ovules or pistils may likewise result in poor set.

(*v*) *Non-viable pollen* :—Insufficient production or availability of pollen and the loss of viability in pollen before it reaches the stigma may bring about a low fruit set.

(*vi*) *Genetic* :—Self-unfruitfulness, self-sterility and low prolific tendencies are heritable factors, which severally and collectively may result in poor set and crop.

(*vii*) *Hybrid condition* :—Hybrids between distantly related forms are known sometimes to produce self-sterility.

(*viii*) *Incompatibility* :—In several deciduous fruits, the pollen of some varieties are incapable of fertilising the flowers of certain other varieties or of the same variety.

(*ix*) *Nutritive* :—Over-bearing in the previous season or defective orchard practices may influence the food availability or synthesis to such an extent as to adversely influence fruit set.

(*x*) *Other internal factors* :—Flowers often exhibit different fruit setting capacities in different parts of the same tree. Health of limb, length and size of terminal growth or fruit-bearing wood, size of foliage etc., may bring about variations in set.

Among the external causes, the most important are the following:—

(1) *Environment* :—Temperature, rainfall and wind are the major influences which favour or prevent the optimum pollination and fertilisation.

(2) *Nutrition* :—The nutritive conditions as affected by soil, water supply, manuring, soil culture, and pruning also exert a profound influence on fruit set. Application of manures and fertilisers to the trees a few days before blossom emergence is generally advocated with the belief that it would favour fruit set.

(3) *Pests and Diseases*:—These account in some years for a considerable failure in fruit set. The hoppers on mangoes are an instance of a pest possessing the ability to destroy blooms completely or preventing their functioning in the natural manner in some years.

Normal shedding is a Nature's device to maintain the equilibrium in the tree. It is only the abnormal shedding that the grower is called upon to tackle, but in doing so it will be clear that the remedy is not by any means simple, and in any case has to be devised by a study of the individual orchard conditions. Of late, a better crop set is claimed to have been secured by certain hormone sprays. Sprays containing alpha napthalene acetic acid at 10 to 15 parts per million, or its salts or amides at 20 parts per million, have been found at Long Ashton to prevent pre-harvest drops of apples and pears, when sprayed about five days before fruit drop is normally expected. Alpha-napthalene compounds are, however, reported to be very variable in results. On the other hand, the 2—4 D compounds are said to have a narrower critical concentration range with a longer duration of effective period. They are also said to be translocated more easily within the plant and are also cheaper in use. As pre-harvest fruit drop sprays, therefore, the 2—4 D compounds have gained greater popular appeal. The material is usually made into a solution with a high grade petroleum spray oil and is then applied at 3 to 10 gallons per acre in the form of a mist to float over the orchard.

Regularity of bearing :—Some varieties of apples and pears tend to bear in alternate years, and are therefore called as biennial bearers. Individual spurs may exhibit the same tendency. This problem has been studied at various angles, but yet there is no effective remedy. This biennial bearing tendency is often confused with the production of lean crops at unregulated intervals, as is exhibited by the mango in South India. The feature of some trees of bearing a small crop after a heavy crop yield in the preceding year, is not to be confused with the rhythmic heavy and low-bearing tendencies, which form the characteristics of some apple and pear varieties. From the practical point of view of the grower, the most dependable method of securing regular bearing is to select varieties which have a strong tendency to bear annually, and to keep the trees in a vigorous condition, so that they will not overbear.

List of References

1. Chandler, W. H.—Fruit Growing, Houghton Mifflin Company, New York, 1925.

2. Gardner, V. R., F. C. Bradford and H. D. Hooker Jr.—Fundamentals of Fruit Production, McGraw Hill Book Company, New York, 1922.

3. Naik, K. C. and M. Mohan Rao.—Cropping Behaviour in Mangoes. Madras Agricultural Journal, July, 1941.

4. „ and M. Mohan Rao—Some Factors Governing Fruit Bud Formation in Mangoes—Studies on Certain Aspects of Growth. Madras Agricultural Journal, October, 1942.

5. Naik, K. C. and M. Mohan Rao—Relation Between Growth and Flowering in Mangoes, Madras Agricultural Journal, November, 1942.

6. ,, and M. Mohan Rao—Blossom Biology and Pollination in Mangoes, Indian Journal of Horticulture, December, 1943.

7. Swarbrick, T. and K. C. Naik—Factors Governing Fruit Bud Formation, Journal of Pomology and Horticultural Science, March, 1932.

8. ,, Growth Regulating Substances in Horticulture, Part II, Journal of the Royal Horticultural Society, Vol. LXXII, Part 9, Sept., 1947.

CHAPTER X

PICKING, PACKING AND MARKETING

PICKING

The time to pick fruits is dependent on the variety and the purpose for which the fruit is meant. The picking stage is also governed by the distance to the market. In most fruits colour changes at the maturity stage are characteristic of the variety. Some fruits like the pears tend to deteriorate in quality when allowed to ripen on the trees, and some varieties like the Kieffer have to be ripened in store before sale. Some peaches fail to colour well after picking, while plums do ; but at the same time if peaches are tree-ripe, they tend to become very soft when they reach the consumer, while if they are picked too soon they will be short of flavour. With mangoes a few tree-ripe fruit drops are a good indication of maturity of the standing crop. In citrus the colour of fruit is an indication of maturity only in certain periods of the year in South India, such as October to February for sweet oranges. In sapotas the colour of flesh just beneath the thin rind changes slightly with the approaching maturity, as also the ground colour of the rind. A distinct softening of the fruit or a change in the firmness of flesh is the index of maturity in figs and grapes. Some peaches when mature will produce a springy feeling or will easily snap off when the fruit is gently lifted up in the hand. In some fruits like the water melons, a slight shrivelling of the fruit stalk and a dull sound when the fruit is tapped, are indications of maturity. Because of these variations, and of the need to pick some fruits generally in a little immature stage for long distance transport, the correct stage of picking has to be determined largely by experience. In some countries pressure testers have been devised to determine the maturity standards. These show the pressure required to puncture the skin and flesh, and provide a good indication of right stage for harvest in fruits which reach maturity at one time.

In soft fruits, the fruits should not be grasped at the time of harvesting, but only the stalk stem. Handling the fruit roughly may also remove the bloom on it, besides injuring the fruit. In grapes the berries may drop off. In most cases the fruits should be picked to a "button", i.e., with a piece of stem on. But this stem should not be too long to injure other fruits while packing or during transport. In many fruits like citrus, pomegranate, grape and mango, it is wise to use a pair of clippers or scissors to cut off the stalk stem neatly and to the required size. Great care is necessary in handling fruit, as the keeping quality depends on the skin being kept in a sound, unbroken condition. It is necessary to go round the trees several times for picking the fruits at the right stage, as all the fruit is not ready at the same time. For tender fruits a basket may be used to collect the harvest, but for hardy fruits a bag may be used for initial gathering and for conveying to a larger basket. The method of attaching a bag to a curved blade fixed at one end of a long pole is common in mango and lime orchards for bulk harvest. Fruit should never be dropped into the bag but should be carefully placed in it. Strong, stable, but light ladders are convenient for tree fruit harvesting operations. Tree climbing for harvesting fruits should be discouraged, as this may cause breakage of limbs or other tree parts. Picking stools also can be used for small trees. It is best to pick fruits early in the morning and not in the warm part of the day, provided the weather is dry. If fruits are covered with dew or are wet by rains, they will be easily bruised. In citrus such bruises cause liberation of peel oil, and this brings about brown spotting on the rind. Thus the fruit is spoiled in appearance and some fungi also are enabled to enter the fruit. Some recommend that citrus fruits should not be picked for two or more days following heavy rains. After picking the fruits should be kept in a cool place away from the direct sun. Else they will ripen quickly and spoil in storage. If fruits have to be picked in the noon when temperature is high, the fruit cases should be kept in the tree shade as soon as they are filled up and taken to the shed for stacking loose overnight to allow the fruit to cool. In citrus fruits it is well-known that the flavour depends upon the development of a certain ratio of sugar to acid present in the juice. Definite ratios have been worked out and prescribed in some countries. Such standards, however, have to be evolved yet for South Indian fruits to determine the right stage for harvest.

Grading :—Grading of fruits on the basis of size and quality is an essential feature of modern marketing. It is also necessary for benefiting the fruit industry itself, since it ensures the supply of fruit of dependable standards of quality to the public and thus inspires their confidence. It also helps the producer by bringing better returns for his crop, by reducing the cost of handling and the resultant losses during the different stages of marketing. Under the Agmark scheme, systematic grading of some fruits has been recently brought into being. These aim to separate the fruits into different grades primarily on the basis of the size of fruits.

Hand grading is slow, costly and not always accurate, though is common in this country with some people; but elsewhere machinery has been extensively employed. The grading or sizing machine for oranges devised by the Agricultural Department, Madras is very useful and is being increasingly utilised. Such machines for grading other fruits are required. Grading according to quality is of great importance but has not yet been devised or adopted in this country in so far as fruits are concerned.

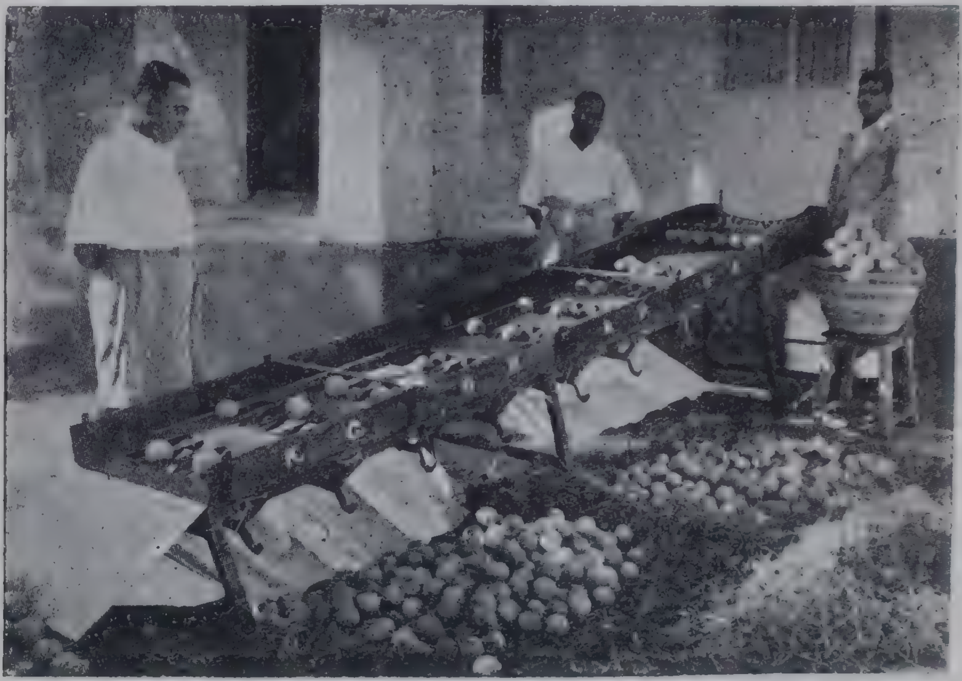


Fig. 28. A cheap grading machine for oranges
(A more efficient but slightly costlier machine is now recommended by the Department.)

Packages :—These are variable in form, shape and size, and are prepared from different material. In this country baskets are more common than boxes or crates for packing fruits. Crates of standardised sizes are the rule in foreign countries especially for distant markets, but are still to become popular in India.

Packing :—It has been recognised in foreign countries that women are better packers than men especially for delicate fruits such as berries and grapes. While packing, each individual fruit or cluster is placed separately and by hand in a well-ordered and attractive manner. For hardy fruits the packing arrangement varies according to the packages and the market demands. For local and fancy markets, special and expensive packages and methods of packing are usually employed. As has been already stressed extreme care in handling fruits both at the time of picking as well as later, till the stage of consumption, is essential. Bruising of fruit causes considerable loss and is common in this country due to careless picking, handling and transport. In the box packing, the boxes may be lined with paper. Several fruits are also commonly wrapped individually with a wrapping paper. The wrap should finish over the stalk, so that a good pad will be formed to prevent stalk injury to other fruits in the pack. Only graded fruits are wrapped. Some packers rub the fruit rinds gently and even apply vaseline to some fruits like the citrus to give a gloss. Chemical treatments are also given sometimes as a precaution against diseases in transit. The packing should always be tight (not slack), and compact ; and the packages should be neatly secured and labelled. In apples, pears and citrus it is customary to finish the pack to allow a slight bulge on the top and bottom. This allows for shrinkage in transit. It is of extreme importance to see that the packing cases are clean and free of rotten fruits or fruit pieces. A little wood wool is useful at the bottom and top of the packing case to serve as a padding. The case should be marked with the name and variety of fruit, its grade, size or count. It is advantageous to wire the cases also for long distance transport. It is a bad practice to stack the cases on lids or bottoms, since the bulges are on these sides.

Storage :—In this country store houses are of ordinary kinds. Cold stores are only becoming important of late, and may play an increasingly important role in the future. Since most fruits are seasonal in their production and are available in plenty in certain months and scarce in others, provision for storage of fruits in periods of glut and for use in seasons of scarcity, becomes a vital necessity. In times of glut and during peak production, the prices are not normally attractive to the producer. To carry over the surplus production for distribution in the off-season months, by holding them in cold storage, is therefore the obvious remedy. Most fruits have to be stored quickly after harvest. Delayed storing, combined with damage in transport leads to a great deal of waste in storage. Cold storage research with South Indian fruit has not been yet done, but there is undoubtedly a great need for it. Refrigeration is also necessary during transport, and on this subject too, sufficient information is lacking at present.

The value of all kinds of fruit stores lies in retarding the chemical changes associated with the fruit ripening process, and also in inhibiting or retarding the growth of disease organisms. Of the several types of cold storages, the most common is that in which the temperature is regulated by refrigeration. The principle of refrigeration is that a gas is first liquified and then allowed to go back into gaseous state again. Ammonia or carbon dioxide is the gas used and this is compressed and passed through cooling coils. The compression and cooling result in the changing of the gas to the liquid state, in which form it is piped to the storage room. During the passage the liquid gas passes through a needle valve into larger pipes, where it expands into gaseous form again. At this point refrigeration begins, as is evidenced by the frost appearance on the large pipes. The expanding gas takes up heat and thus lowers the air temperature in the storage. When the gas returns to the compressor, the process is again repeated. This is the direct expansion method. In another method the gas is used to cool a solution of brine, which is then piped into the storage room.

Air-cooled storages have been used in some places for prolonging the life of fruits. The principle in these is to introduce cooler night air into a room and then keep the room closed for a time on the following day. Such rooms have to be insulated to be effective. In ordinary stores also the aim should be to provide as cool conditions for fruits as possible. Special precautions should be taken in all types of storage to see that unsound or diseased fruits are not mixed with sound fruits in storage or in packages.

The storage life of fruits varies between species and varieties. and also depends on the cultural practices, and on the soundness of the fruit.

Transportation :—In South India rail and road transports are not generally designed to suit the fruit trade. The grower is therefore compelled to use the facilities as they are found. The scope for improvement as well as to reduce the cost on transport is great, but these can only be done when group action by producers becomes more tangible than at present. The growers can individually help in keeping down the losses by using strong sturdy packages, by compact and firm packing, by careful handling of fruits, and by using spring carts or trucks provided with good springs to prevent excessive jolting.

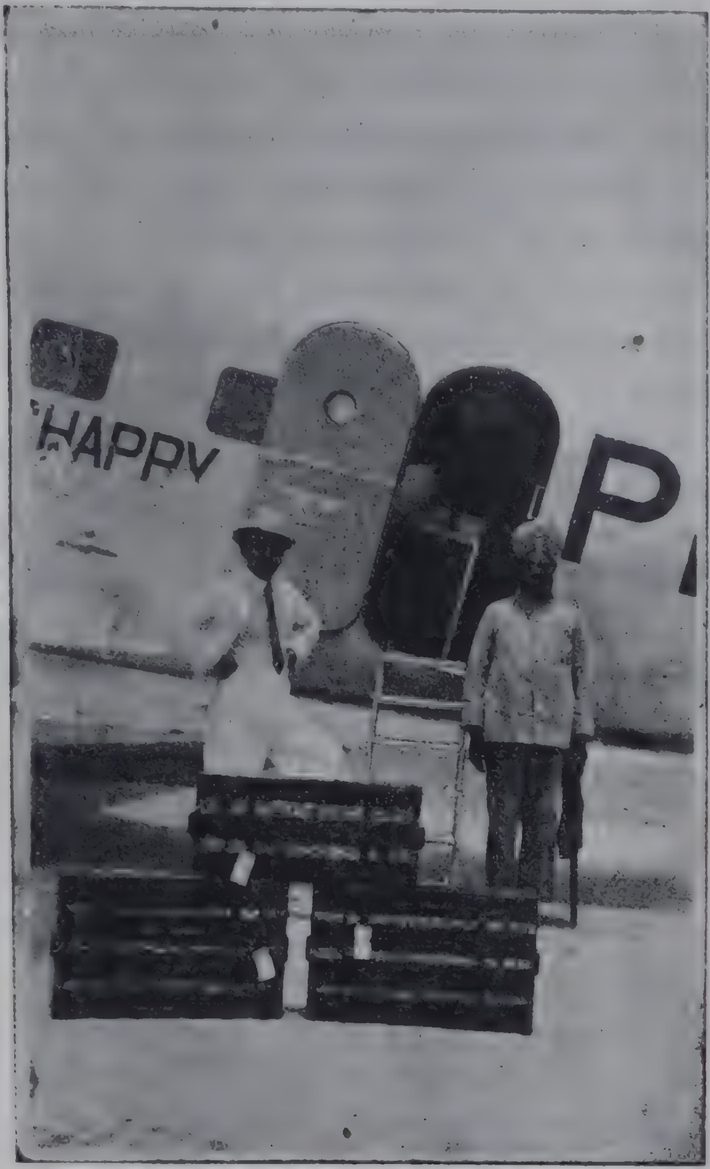


Fig. 29. Fruit crates for transport by air

Marketing :—Successful fruit production demands care and vigilance all along the line, and this is no less so in the matter of disposal of fruits. As a matter of fact, satisfactory disposal is the culmination of the profession in which the grower is engaged, though it must be said that this last stage is one to which most of the producers are rarely fitted and on which they play at present only an inconspicuous part. The reason for this unsatisfactory state of affairs is that, while the production of fruit is primarily a work for the individual's initiative, the work of marketing is eminently suited for group action. Nowhere in the fruit world the individual grower has been able to hold his own for a long period. In South India such individual attempts in the marketing of fruits has only served to strengthen the position of the organised commission agents, brokers and middle-men, who very often reap much larger and more assured profits in a short time than the producers. The sale is effected either by consignments to commission agents or to middle-men who purchase the standing crop. The middle-men or contractor may, in his turn, be a broker of a commission agent. When the fruits reach the markets, the commission agents sell them either in open auction or through retailers. While the commission agent is safe with his assured fee, the producer's receipts are subject to the law of supply and demand. The loss in transit and on pilfering en route are debited to the producer. The consequence of periodic gluts in markets, largely due to unregulated movement of produce, have also to be borne by the producers. Co-operative organisations of producers have been attempted to secure the rightful share of the consumer's rupee to the growers, but these are yet to make sufficient head-way as to bring about a change for the better.

A detailed discussion of marketing of fruits is outside the scope of the present book. For a general idea relating to the problems of marketing of some of the Indian fruits, the readers will find it of interest to refer to the publications issued by the Agricultural Marketing Adviser to the Government of India, a list of which together with some publications of allied interest are given below.

List of References

1. Agricultural Marketing Adviser to the Government of India—Report on the Marketing of Cashew Nuts in India, Marketing Series No. 47, 1944.
2. Agricultural Marketing Adviser to the Government of India—Report on the Marketing of Citrus Fruits in India, Marketing Series No. 43, 1943.
3. Agricultural Marketing Adviser to the Government of India—Report on the Marketing of Bananas, Marketing Series No. 49, 1945.
4. Agricultural Marketing Adviser to the Government of India—Report on the Marketing of Grapes in India, Marketing Series No. 20, 1940

5. Naik, K. C. & S. Sugurappa—Quality Grading of Sathgudi Oranges, Indian Farming, Vol. IV, 5, 1943.

6. Naik, K. C.—A Study of Orange Marketing in England, Agriculture and Live Stock in India, March, 1932.

7. „ A Study of Marketing of Bihar Fruits at Calcutta, Dept. Agri., Bihar & Orissa, Bull. No. 1, 1935.

PART II

CHAPTER I

INDIVIDUAL FRUITS

MANGO (*Mangifera indica*)

It will be hard to think of a fruit which has appealed to the people of this country in a greater measure than the mango. Recognised as one of the choicest fruits of the tropics, mango has been raised from times immemorial in India, attaining an importance unexcelled in any other part of the world. From the point of view of acreage and production, it is easily the most outstanding of all Indian fruits. The adaptability of this fruit to a very wide range of climatic and soil conditions, the relatively hardy nature of the tree, the low cost of its raising and maintenance, the high tree yields, the healthful dietetic qualities of the fruit, and above all its very widespread popularity as one of the choicest table fruits have contributed to accord the premier place to the mango in all parts of the country.

Production and Acreage :—The South India, as the rest of the country, has about or more than 50 per cent. of the orchard area devoted to the mango. The presidency of Madras claims roughly 250,000 acres under this fruit out of the estimated area of about 500,000 acres under cultivated fruits. The production of the fruit is of the order of about 855,000 tons per annum, a figure excelled only by bananas in this part of the country. In normal years, about 21,200 tons of the above production are exported outside the presidency every year to distant centres as far as the Punjab, North-West Frontier and Bengal and occasionally even to Burma, Ceylon and Straits Settlements.

The leading centres of mango production in South India are Malabar with a normal area of about 50,000 acres, Vizagapatam with about 40,000 acres, East Godavari with about 30,000 acres, Chittoor with over 25,000 acres, North Arcot and Cuddapah districts with a rough area of about 14,000 acres under each. Mysore with about 13,000 acres, Cochin and Travancore States with equally large but yet undetermined areas also form important centres of mango production, the first of these exporting about 100 tons of fruit per year to Madras Presidency in normal years.

Climate :—Mangoes are cultivated in every province of India, almost in every district excepting on elevations exceeding about 4,000 feet above the mean sea level. Its commercial importance is, however, largely limited to elevations below about 3,000 feet. In tracts subject to severe winter conditions and to frequent frost occurrences or to hail storms and cyclonic weather, mango is liable to periodic crop failures and serious vicissitudes during the early life of the plantation. Heavy rains during flowering and fruit maturity periods are also destructive to the mango crop. The latter feature is one of the reasons why late varieties fail to mature successfully in the West Coast, where the heavy rains at the commencement of the south-west monsoon cause both large amount of shedding of fruit and various forms of other fruit damages. In general, dry weather and cloudless sky at flowering and fruit ripening period are considered favourable for success. A dry season immediately preceding the period of blossom emergence is also helpful, since such a feature fosters cessation of growth, which is a necessary pre-requisite for preventing the trees running into excess of vegetative growth at the expense of flower production during the normal blossoming season. Heavy rains may also wash off the pollen and prevent fruit set, while a high atmospheric humidity at the flowering season may favour fungal attack on the inflorescences. Erratic crop production is a special feature of most of the mango varieties under cultivation, and this is largely governed by seasonal conditions. In particular, the early ripening in mangoes grown in the West Coast, the production of off-season crops in some parts of Tamilnad, and the variation in yields in different years are mainly attributable to seasonal influences. The heavy and late rains during 1940 and in 1946 have for example resulted in prolonging the extension growth of shoots towards the close of these years, thus preventing a good blossom emergence on one hand, and encouraging on the other, the production of an off-season crop of flowers in many varieties in 1941 and in 1947. Dry and relatively rainless summers, evidently help the shoots to get the desired rest period for successful initiation of flower buds. The ability of several varieties to produce more than one crop of flowers and fruits in a year when one is destroyed, thereby prolonging the fruiting season, is a unique feature of South India, favoured as it is by entire absence of frost, hail storms and severe winter conditions, as well as due to the long growing seasons on its vast plains.

Soils:—Provided the soil is not highly water-logged, alkaline, rocky, extremely shallow or otherwise too poor for any crop, mango can be grown on it. Being one of the least exacting of South Indian fruits in its soil requirements, it is adaptable to a wide range of soil conditions. It however prefers a deep, moderately rich and well-drained soil, thriving equally well in light and heavy soil media provided other conditions are favourable. Poor stony soils on apparently barren hill slopes have often been selected for the mango. Under such conditions the grafted trees remain dwarfed, appearing sickly or ragged with sparse foliage and yet producing abundant crop for the tree size. Luxuriant growth accompanied by scarce and irregular crop yields are commonly associated with trees planted in very fertile and deep clay soils. Uneconomic harvests are the end results of raising mango plantations on ill-drained soils or on extremely light, sandy or gravelly or shallow soils of only a few inches depth. Due to the enormous foraging power of its roots, stray mango trees standing on apparently rocky hill slopes, often raise themselves to majestic heights and proportions and are overladen with crop, provided the rock does not form a continuous barrier in the path of the roots in the soil media and the rest of the soils is well-drained, deep and uniform textured. This last feature is of especial importance ; for on many soils where farm crops usually give good yields, the mango has often failed to grow and fruit because of sudden variations in soil texture within small depths. Where heavy sub-soils are superimposed by open-textured layers, the trees come quickly to grief, even if large holes are made at the planting time and are filled with transported soil of good texture and fertility. Tree distress under such conditions is typified by sparse foliage and burnt leaf margins and tips. The coastal sandy belts comprising of almost pure sand have also been used for mango growing particularly in heavy rainfall areas. Under such conditions, frequent watering and manuring become necessary to keep pace with the rapidly losing moisture and nutrients in the soil. When the roots penetrate down to a moist layer, watering may become unnecessary, but regular manuring cannot be dispensed with, if profitable yields are to be secured. From the point of economy in production cost, a loamy soil of good depth has much to commend it over other soils, although good profits may often be secured by choosing even soils of extreme texture, in parts where production is relatively limited in size.

VARIETIES

A very large proportion of the mangoes produced in this country at present are from trees raised from seed. Since mango is cross-pollinated and most of the mangoes produce only one seedling per seed, being mono-embryonic, planting of seeds of superior mango varieties with the hope of securing the same sorts is certain to lead to disappointment, excepting in the case of a few races which produce more than one seedling per seed, and are therefore known as polyembryonic. In such polyembryonic races, only one seedling is likely to be the sexually produced, being the result of crossing between two different trees or varieties. According to some workers, the sexual seedling does not at all arise from seeds of the polyembryonic mangoes. Whatever that may be, the sexual seedling does not resemble the parent, while the asexual seedlings do. In South India about ten polyembryonic races are under cultivation, Olour being one of the most extensively known and cultivated largely in Malabar. Some of the mono-embryonic varieties also when cross-pollinated with polyembryonic mangoes either by chance in Nature or artificially produce asexual seedlings in the resulting progenies. All polyembryonic races are being largely grown from seed in the West Coast of South India and are found to produce trees remarkably true to their parents. On the other hand, seed propagation in the case of other commercial varieties which are mono-embryonic, is valueless as the single seedling more often than not produces only inferior trees. However, seedlings of superior quality occasionally arise from seed due to chance mating in Nature ; and this offers a means of augmenting the collection of superior mango varieties. The original seedling trees of such superior mangoes as Mundappa in Mangalore and Chinna Suvarnarekha in Vizag district are still alive. By vegetative propagation methods, such trees have been extensively multiplied true-to-type so as to form a significant part of the present South Indian mango production.

In South India over 350 varieties of mangoes are known to be under cultivation and are being multiplied in commercial fruit nurseries vegetatively for sale to the public. Success in mango growing demands that the varieties that one intends to plant must be productive, regular bearing, of good quality and suitable to the tract or site. If these objectives are borne in mind the varieties left for selection by the grower in a given tract will be very limited. It is true that opinions differ as to the best variety of mango, in the same manner as tastes differ. Notwithstanding this, the varietal peculiarities and preferences to a given region are so great and varied that the necessity for a very careful selection cannot be over-emphasized.

Without an accurate understanding of varietal habits and characteristics or without a standardised system of varietal classification and nomenclature, selection of varieties is difficult, if not impossible, especially in mango with its extensive range of varieties. It is of considerable importance to the grower to be able to identify not only the ripe fruit but also the trees thereof in nursery and orchard. There can never be a *status quo* in mango variety situation. The origin of new varieties in Nature first, as chance seedlings and subsequently, by perpetuation of such superior chance seedlings as clones, leads to a constant shifting of variety preferences in nurseries and orchards. This process of adding new varietal names has been going on for centuries, some of the nurserymen exploiting the feature by coining fanciful names and endeavouring to sell plants with exaggerated varietal claims. The innumerable varietal names have caused such a great deal of confusion that, it has in a great measure hampered the progress of the mango industry by preventing the extension of areas under really superior varieties, inviting at the same time ridicule from workers in foreign countries, who have rightly asserted that some of the Indian mango varieties exist only in the imagination of the nurserymen.

In the matter of variety selection and identification, the growers' guide at present is primarily the nurseryman's catalogue. These publications, which in many cases are mere compendiums of errors and synonyms, have caused considerable disappointment to the growers. Correct varietal descriptions are also indispensable to mango research and extension workers. Even the users of mango are becoming more and more quality conscious and therefore variety conscious. For efficient marketing and for utilisation of mango in canning and product factories also, varietal identification becomes imperative. A detailed study of mango nomenclature and classification has therefore been undertaken at the Fruit Research Station, Kodur with a view to provide an insight into the problem of variety

SOUTH INDIAN MANGOES

- Fruit Roundish.
  - Beak missing or a point.
    - Leaf tip acute.
      - Leaves flat-i.
      - Leaves slightly or strongly folded-ii.
    - Leaf tip sub-acuminate or acuminate.
      - Leaves flat-iii.
      - Leaves slightly or strongly folded-iv.
  - Beak distinct to prominent.
    - Leaf tip acute.
      - Leaves flat-v.
      - Leaves slightly or strongly folded-vi.
    - Leaf tip sub-acuminate or acuminate.
      - Leaves flat-vii.
      - Leaves slightly or strongly folded-viii.
- Fruit Intermediate.
  - Beak missing or a point.
    - Leaf tip acute.
      - Leaves flat-ix.
      - Leaves slightly or strongly folded-x.
    - Leaf-tip sub-acuminate or acuminate.
      - Leaves flat-xi.
      - Leaves slightly or strongly folded-xii.
  - Beak distinct to prominent.
    - Leaf tip acute.
      - Leaves flat-xiii.
      - Leaves slightly or strongly folded-xiv.
    - Leaf tip sub-acuminate or acuminate.
      - Leaves flat-xv.
      - Leaves slightly or strongly folded-xvi.
- Fruit markedly long.
  - Beak missing or a point.
    - Leaf tip acute.
      - Leaves flat-xvii.
      - Leaves slightly or strongly folded-xviii.
    - Leaf tip sub-acuminate or acuminate.
      - Leaves flat-xix.
      - Leaves slightly or strongly folded-xx.
  - Beak distinct to prominent.
    - Leaf tip acute.
      - Leaves flat-xxi.
      - Leaves slightly or strongly folded-xxii.
    - Leaf tip sub-acuminate or acuminate.
      - Leaves flat-xxiii.
      - Leaves slightly or strongly folded-xxiv.

Fig. 30. A key to the identification of mangoes.

(For descriptions of varieties under i to xxiv, refer to page 126 and onwards.)

selection based on an accurate recognition of the important varietal characteristics of South Indian mangoes. The system of classification presented in Figure 30 is a result of that study. Only the most important diagnostic features of the leading commercial varieties of South Indian mangoes are given in the following pages, as based on the above-mentioned classification.

VARIETAL DESCRIPTIONS

I - 1 - LADDU:—Fruit medium, base flattened, cavity shallow, shoulders equal, level and rounded, beak absent, sinus slight to absent, skin fairly thick, leathery and yellowish ; flesh firm to meaty and fibreless, eating quality good. Bearing moderately abundant in mid-season.

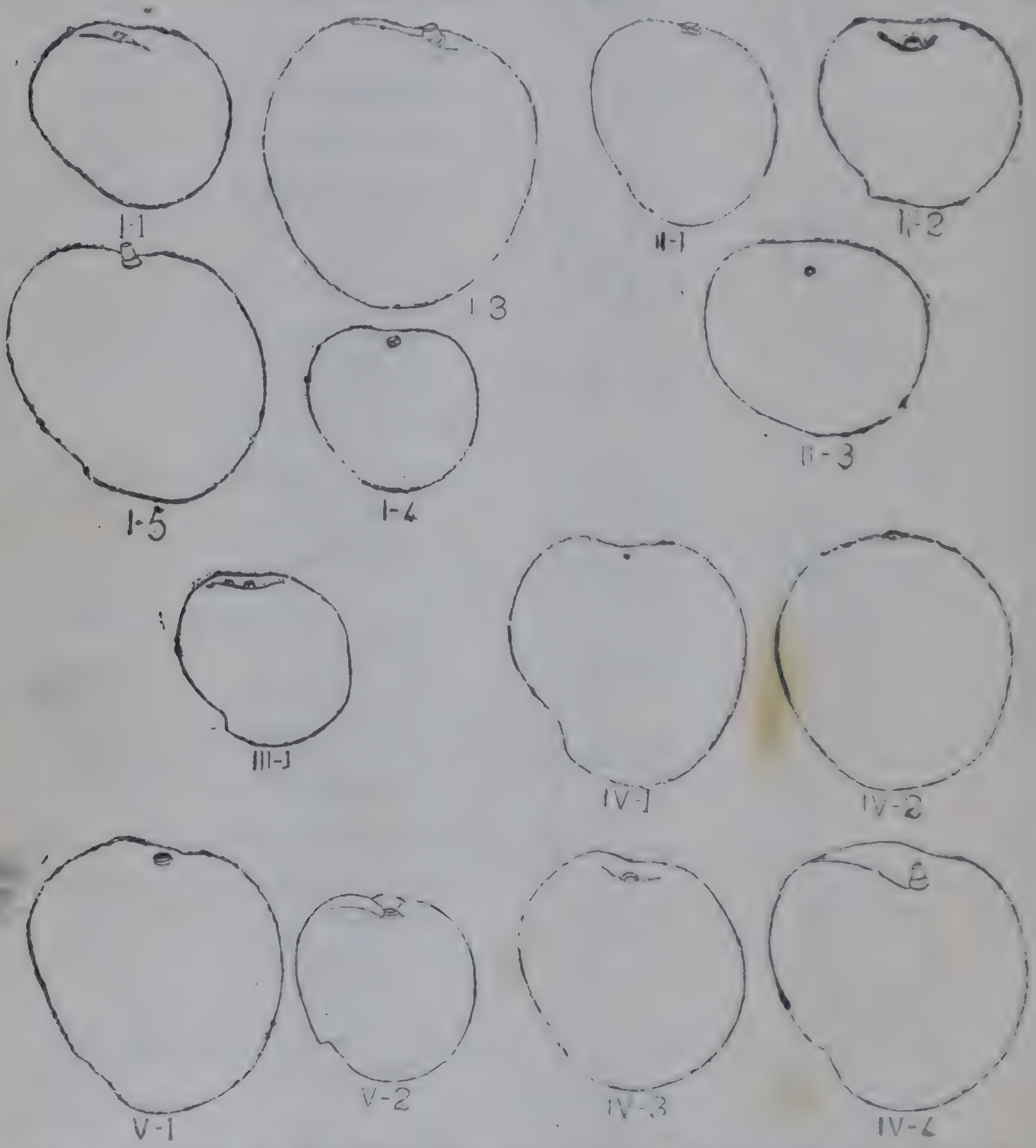


Fig. 31. Mango fruit sketches (Laddu to Benazir) except Peta Theya Mamidi.

I-2- Peta Theya Mamidi:—Fruit large, ovate roundish, base flattened, cavity deep, dorsal shoulder rounded and equal with ventral, sinus slight to absent, skin fairly thick and rough, and yellowish; flesh soft, slightly fibrous; eating quality medium as a table fruit but good as a raw fruit. Bearing medium and early.

I-3- Ennamandala Theya Mamidi:—Fruit large, roundish, base obliquely flattened, cavity slight to shallow, ventral shoulder slightly higher than the dorsal, beak absent, sinus absent, skin thick, tough, smooth and yellowish; flesh soft and sparsely fibrous; eating quality medium when ripe but good when raw. Bearing medium, in mid-season.

I-4- Desavali Theya Mamidi (syn. Nuzvid Theya Mamidi):—Fruit small to medium, base flattened, shoulders equal, level and rounded, sinus slight, skin medium thick, leathery, smooth and yellowish with a blush; flesh soft and slightly fibrous near the stone; eating quality good when raw and medium when ripe. Bearing heavy and early.

I-5- Black Alphonso (syn. Kala Ishada, Kala Appus):—Fruit large and ovate roundish, base slightly flattened, shoulders equal, sinus slight, skin thick, fairly rough and yellowish; flesh firm and fibreless; eating quality very good. Bearing medium, in mid-season.

II-1- Moolky No. 1:—Fruit medium and ovate roundish, base slightly obliquely flattened, ventral shoulder slightly higher than the dorsal, sinus absent, skin medium thick, deep chrome coloured; flesh firm and fibreless; eating quality good. Bearing poor and in mid-season.

II-2- Rumani:—Fruit medium and roundish, base flattened, shoulders equal and level, beak a point, sinus shallow, skin thin and yellowish with a red blush; flesh firm to meaty and fibreless; eating quality medium to good. Bearing heavy, in mid and late seasons, often producing an off-season crop. Fruit keeps well.

II-3- Sannakulu (syn. Hamilton):—Fruit medium to large, rounded to peento form, base flattened, shoulders equal, beak and sinus absent, skin medium thick and yellowish; flesh firm and fibreless; eating quality good. Bearing heavy, in mid-season. Keeping quality good.

III - 1 - ATHIMADURAM:—Fruit small to medium and roundish, base slightly flattened, shoulders equal, beak a point, sinus slight to shallow, skin medium thick and yellowish; flesh firm, salmon orange-coloured and slightly fibrous; eating quality good. Bearing medium and in mid-season. Keeping quality good.

IV - 1 - YERRA MULGOA:—Fruit large, ovate roundish, base slightly flattened, shoulders equal, beak absent, sinus shallow, skin medium thick and yellowish; flesh soft and fibreless; eating quality good. Bearing poor to medium.

IV - 2 - NAZEEMPASAND (syn. NAZEEMKHANPASAND):—Fruit medium to large, base rounded and extended, shoulders equal, beak a point, sinus absent, skin medium thick and mustard yellow in colour; flesh firm and fibreless; eating quality good. Bearing medium to poor, and late. Fruits keep well.

IV - 3 - MUNDAPPA:—Fruit medium to large, base slightly flattened, shoulders equal, beak and sinus absent, skin thin, deep chrome coloured; flesh firm and fibreless; eating quality good. Bearing heavy, from mid to late season. Keeping quality good.

IV - 4 - ANDERSON (syn. ASSAL ANDREWS):—Fruit large and roundish oblique, base slightly flattened, ventral shoulder slightly higher than the dorsal, beak absent, sinus slight, skin thick, tough, smooth and yellowish; flesh firm and fibreless; eating quality good. Bearing poor and late. Keeps well.

V - 1 - CHOTA JEHANGIR:—Fruit large and roundish oblique, base obliquely flattened, ventral shoulder slightly higher than the dorsal, beak slightly prominent, sinus absent, skin medium thick and yellowish; flesh soft and fibreless; eating quality good. Bearing medium to heavy in mid-season.

V - 2 - BENAZIR:—Fruit small and ovate roundish, base slightly flattened, shoulders equal, beak distinct, sinus absent, skin medium thick, smooth and yellowish; flesh soft and fibreless; eating quality good. Bearing medium, in mid-season.

VI - 1 - BHUTTO:—Fruit large, peento to ovate roundish, base flattened and extended, shoulders equal, beak prominent, sinus absent, skin medium thick and light yellow coloured; flesh firm and fibreless; eating quality good. Bearing medium, in mid-season. Keeps well.

VI - 2 - PACHARSI:— Fruit small and roundish cordate, base rounded to slightly flattened, ventral shoulder slightly higher than the dorsal, beak distinct, sinus absent, skin smooth, medium thick, leathery and yellow ; flesh soft and moderately fibrous ; eating quality good. Bearing heavy and early.

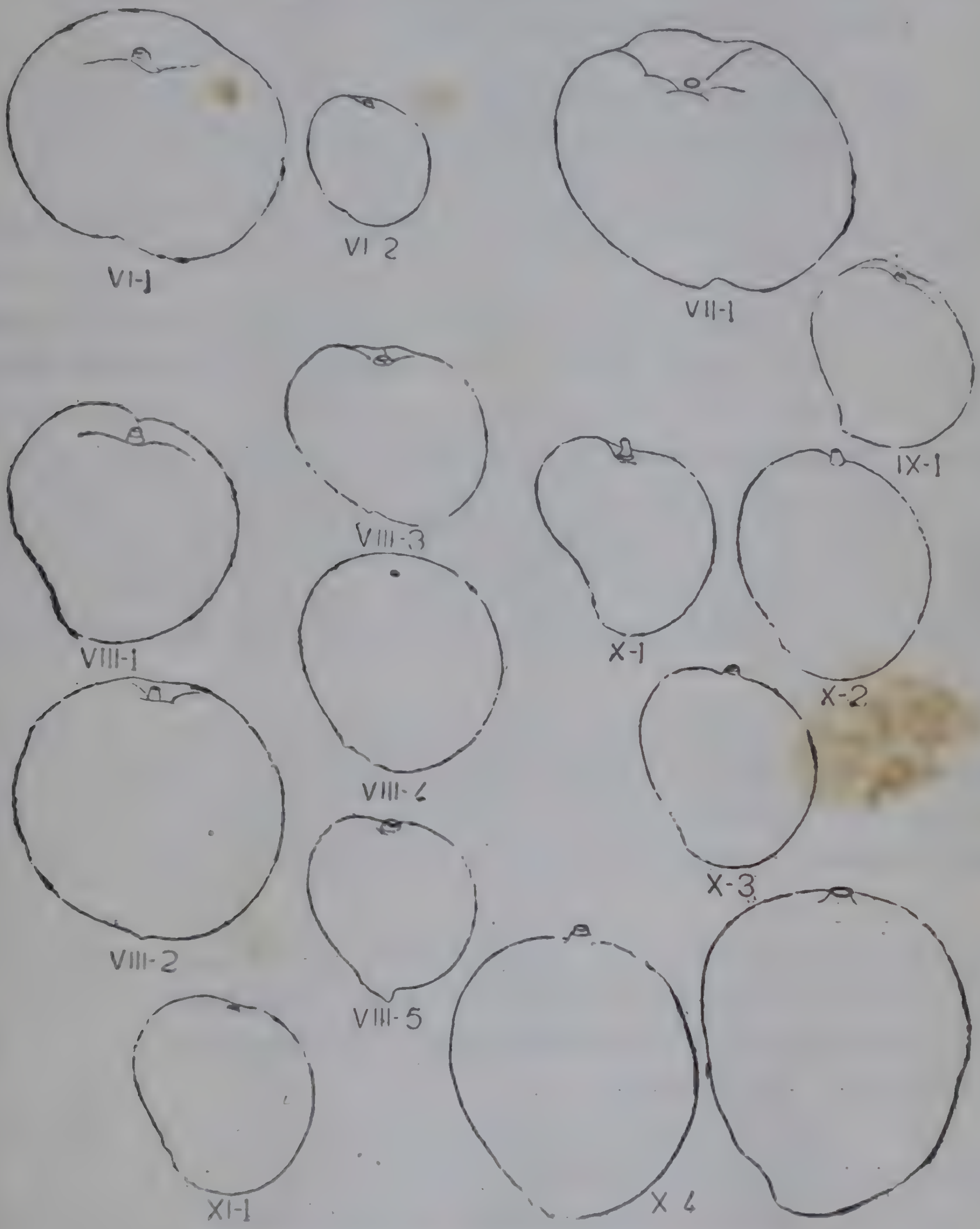

VI-1
VI 2
VII-1
IX-1
VIII-3
VIII-1
X-1
X-2
VIII-4
VIII-2
X-3
VIII-5
XI-1
X 4

Fig. 32. Mango Sketches. (Bhutto to Jehangir.)
(Distinct beak is missed in VI-1 and VIII-1.)

VII - 1 - Nalla Andrews:—Fruit large and ovate roundish, base flattened, shoulders equal, beak prominent, sinus absent, skin medium thick, rough and yellowish ; flesh firm and fibreless ; eating quality good. Bearing medium, in mid-season.

VIII - 1 - MULGOA (syn. MULGOBA):—Fruit large and roundish oblique, base obliquely flattened, ventral shoulder higher than the dorsal, beak distinct, sinus absent, skin medium thick and yellowish; flesh firm and fibreless; eating quality good. Bearing poor and late. Keeping quality good.

VIII - 2 - OCTONUMBER MULGOA:—Fruit large and roundish, base flattened, shoulder equal, sinus absent, beak distinct, skin medium thick and yellowish; flesh firm and fibreless; eating quality good. Bearing medium, in mid to late season. Keeps well.

VIII - 3 - KADRI:—Fruit medium and cordate, base flattened, shoulders equal, beak distinct, sinus absent, skin medium thick and yellowish; flesh firm to meaty and fibreless; eating quality good. Bearing medium, in mid-season. Keeping quality good.

VIII - 4 - PANCHAVARNAM:—Fruit medium and roundish, base slightly flattened, shoulders equal, beak distinct, sinus absent, skin medium thick and yellowish; flesh firm and fibreless; eating quality good. Bearing medium, in mid to late season. Keeps well.

VIII - 5 - KODETHOOR:—Fruit medium to small and roundish, base slightly flattened, shoulders equal, beak in-curved, sinus absent, skin medium thick and deep chrome coloured; flesh firm and fibreless; eating quality good. Bearing heavy and early.

IX - 1 - KALEPAD (PANYAM):—Fruit big and ovate, base slightly flattened, shoulders equal, beak a point, sinus slight, skin thick and yellowish with an orange blush; flesh meaty and fibreless; eating quality medium to good. Bearing medium and in mid-season. Keeps well.

X - 1 - FIRGANGILUDWA:—Fruit medium and ovate oblique, base slightly flattened, ventral shoulder higher than the dorsal, beak absent, sinus shallow, skin membranous and yellowish; flesh firm and moderately fibrous; very juicy; eating quality very good. A high class juicy variety with bearing medium to heavy, in mid-season.

X - 2 - YERRAKAVALU BARAMASI:—Fruit medium and ovate oblique, base obliquely flattened, ventral shoulder higher than the dorsal, beak a point, sinus slight, skin medium thick and yellowish; flesh firm and fibrous; eating quality medium to good. Bearing medium, in mid and off-seasons.

X - 3 - NEELUM (syn. KAJALADDU):—Fruit medium and ovate oblique, base obliquely flattened, ventral shoulder higher than the dorsal, beak a point, sinus shallow, skin medium thick and yellowish; flesh fibreless; eating quality medium to good. Bearing heavy and often more than once in a year. Keeps well.

X - 4 - GADDEMAR (syn. PICKLE):—Fruit large and ovate, base slightly flattened, shoulders equal, beak a point, sinus slight, skin medium thick and yellowish; flesh soft and sparsely fibrous; eating quality poor as a table fruit but good for culinary use. Bearing in mid and late seasons.

X - 5 - JEHANGIR (syn. UMDRA):—Fruit large and ovate, base slightly flattened and extended, beak and sinus absent, skin thick, rough, tough and deep chrome coloured; flesh firm to soft and fibreless; eating quality very fine. Bearing very poor and in mid-season. This is one of the choicest table varieties of South India.

XI - 1 - TARIPADI:—Fruit medium and ovate oblique, base obliquely flattened, ventral shoulder higher than the dorsal, beak a point, sinus absent, skin thick and yellowish; flesh firm, fibreless and orange coloured; eating quality good. Bearing heavy to medium. Keeps well.

XII - 1 - ALPHONSO (syn. KHADER, KHADARPASAND, GUNDU, BADAMI, PATANJALI, APPUS, KAGDI HAPUS, ALFONSO):—Fruit medium and ovate oblique, base obliquely flattened, ventral shoulder broader and higher than the dorsal, beak absent or a point, sinus slight, skin medium thick and yellowish; flesh firm and fibreless; eating quality good to very fine. Bearing medium to heavy in mid-season. Keeping quality good. This is reckoned as one of the best mangoes in many parts of South India, though it is not as highly esteemed as the Ratnagiri Alfonso in Bombay markets.

XII - 2 - KOTHAPALLI KOBBARI (syn. KOBBARI MAMIDI):—Fruit medium and ovate oblique, ventral shoulder higher than the dorsal, beak absent, sinus slight, skin medium thick and yellow; flesh firm to soft, juice plentiful; eating quality good. Bearing heavy and in mid-season. A popular juicy variety in the Circars.

XII - 3 - PEDDA SUVARNAREKHA (syn. PULEPALLI SUVARNAREKHA) :—Fruit large and ovate, base slightly flattened, shoulders equal, beak a point, sinus slight, skin thick and yellowish with a scarlet red blush ; flesh soft and fibreless ; eating quality good. Bearing poor and in early or mid-season. This is believed to have given rise to the more famous variety that follows in the form of a chance seedling.

XII - 4 - SUVARNAREKHA (syn. CHINNA SUVARNAREKHA, SUNDRI, SWARNAREKHA) :—Fruit medium and ovate oblong, base

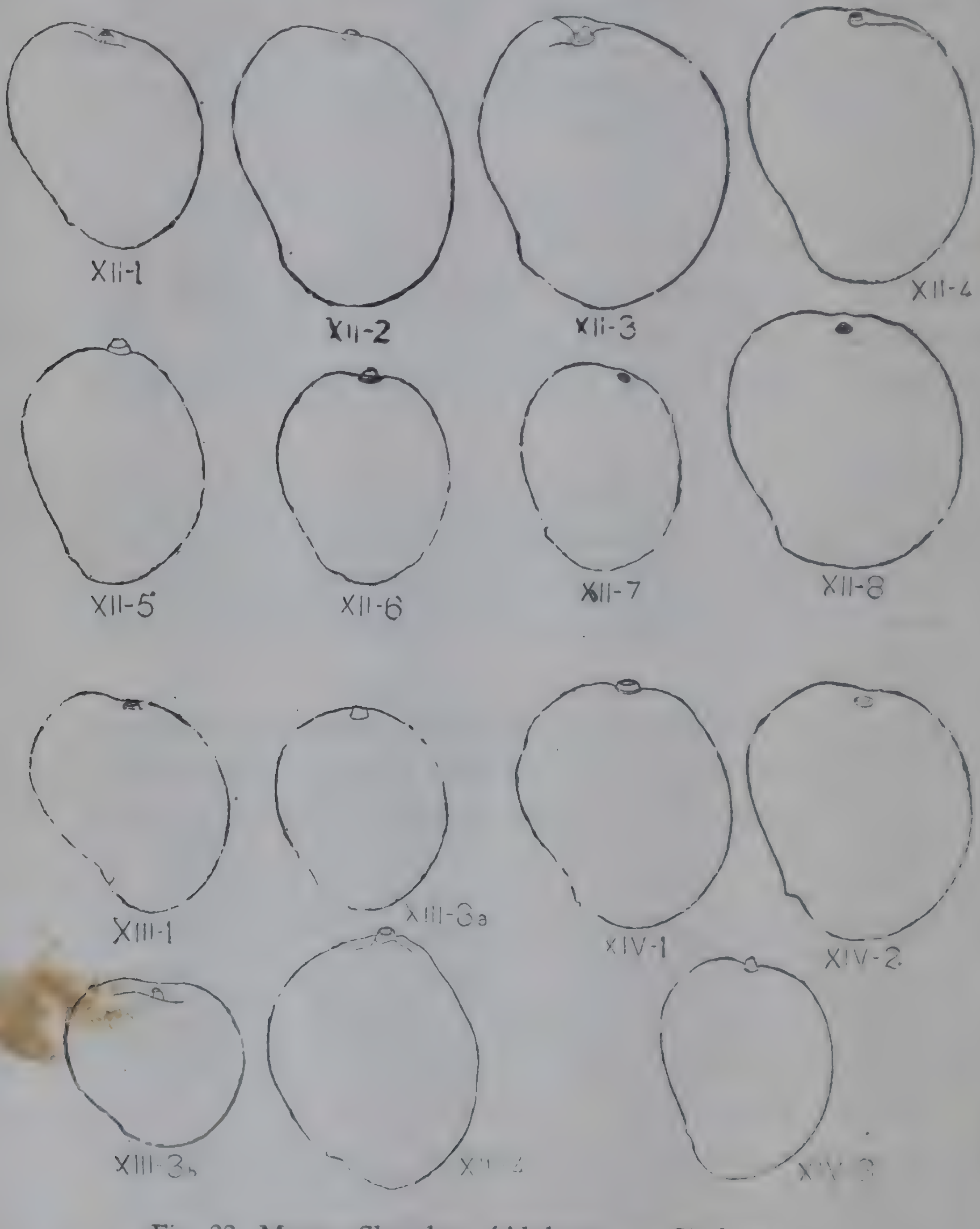


Fig. 33. Mango Sketches. (Alphonso to Sindura.)

Note:- XIII-1 in this Fig. should read as XIII-2. Amrutakalasa is missed. XIII-3b is also known as Sakargutli, but is of inferior quality.

medium thick and yellowish with an attractive and prominent slightly flattened, shoulders equal, beak a point, sinus slight, skin scarlet red blush ; flesh soft and fibreless, juice fairly abundant ; eating quality good. Bearing early and heavy. Keeping quality moderately good. This is a popular and dependable variety under commercial cultivation in the Circars.

XII - 5 - OLOUR:—Fruit medium, oval with rounded base, shoulders level, beak a point, sinus slight, skin thick and yellowish; flesh soft and moderately fibrous, fairly juicy ; eating quality medium. Bearing heavy and very early. This is one of the earliest mangoes appearing in the Indian markets. Being polyembryonic, it is raised extensively by seed in Malabar.

XII - 6 - BENNET ALPHONSO (syn. BENNET APPUS):—Fruit medium and ovate, base slightly flattened, shoulders level, beak slight and a point, sinus slight, skin medium thick and yellowish ; flesh firm and fibreless, fairly juicy ; eating quality good to very good. Bearing heavy and early. Keeping quality medium to good.

XII - 7 - FERNANDIN (syn. FERNANDINO):—Fruit small and obliquely flattened, ventral shoulder higher than the dorsal, beak a point, sinus absent, skin medium thick and yellowish ; flesh meaty and fibreless, fairly juicy ; eating quality good to very good. Bearing medium in mid or late season. Keeps well.

XII - 8 - HAFEEZ-BE-GOLA:—Fruit large and ovate, base slightly flattened, shoulders level, beak a point, sinus shallow, skin medium thick and greenish ; flesh soft and fibreless, fairly juicy ; eating quality good. Bearing medium and in mid-season.

XIII - 1 - AMRUTHAKALASA:—Fruit medium and ovate, base slightly flattened, shoulders level, beak distinct, sinus absent, skin medium thick and yellowish ; flesh firm and fibreless ; eating quality good. Bearing medium and in mid-season. (*Not found in Fig.* 33).

XIII - 2 - GURUVAM:—Fruit medium and ovate oblique, base obliquely flattened, ventral shoulder higher than the dorsal, beak distinct, sinus shallow, skin medium thick and yellowish ; flesh soft and densely fibrous ; eating quality good. Bearing medium and in mid-season. (*Shown as XII - 1 - in Fig.* 33).

XIII - 3a - SAKARGUTLI:—Fruit medium and ovate, base rounded, shoulders equal, beak distinct, sinus slight, skin thin and yellowish ; flesh soft and fibreless ; eating quality medium to good. Bearing medium and in mid-season. (XIII - 3b in Fig. 33 has the same name but is inferior in quality).

XIII - 4 - MADHAVARAOPASAND:—Fruit medium and oval, base tapering, shoulders level, beak distinct, sinus absent, skin medium thick, leathery and yellowish ; flesh meaty and fibreless ; eating quality good. Bearing medium and in mid-season. Keeps well.

XIV - I - AMRUTARASAYANAM:—Fruit medium and ovate, base slightly flattened, shoulders level, beak and sinus slight, skin smooth, thick, leathery and yellowish ; flesh soft and moderately

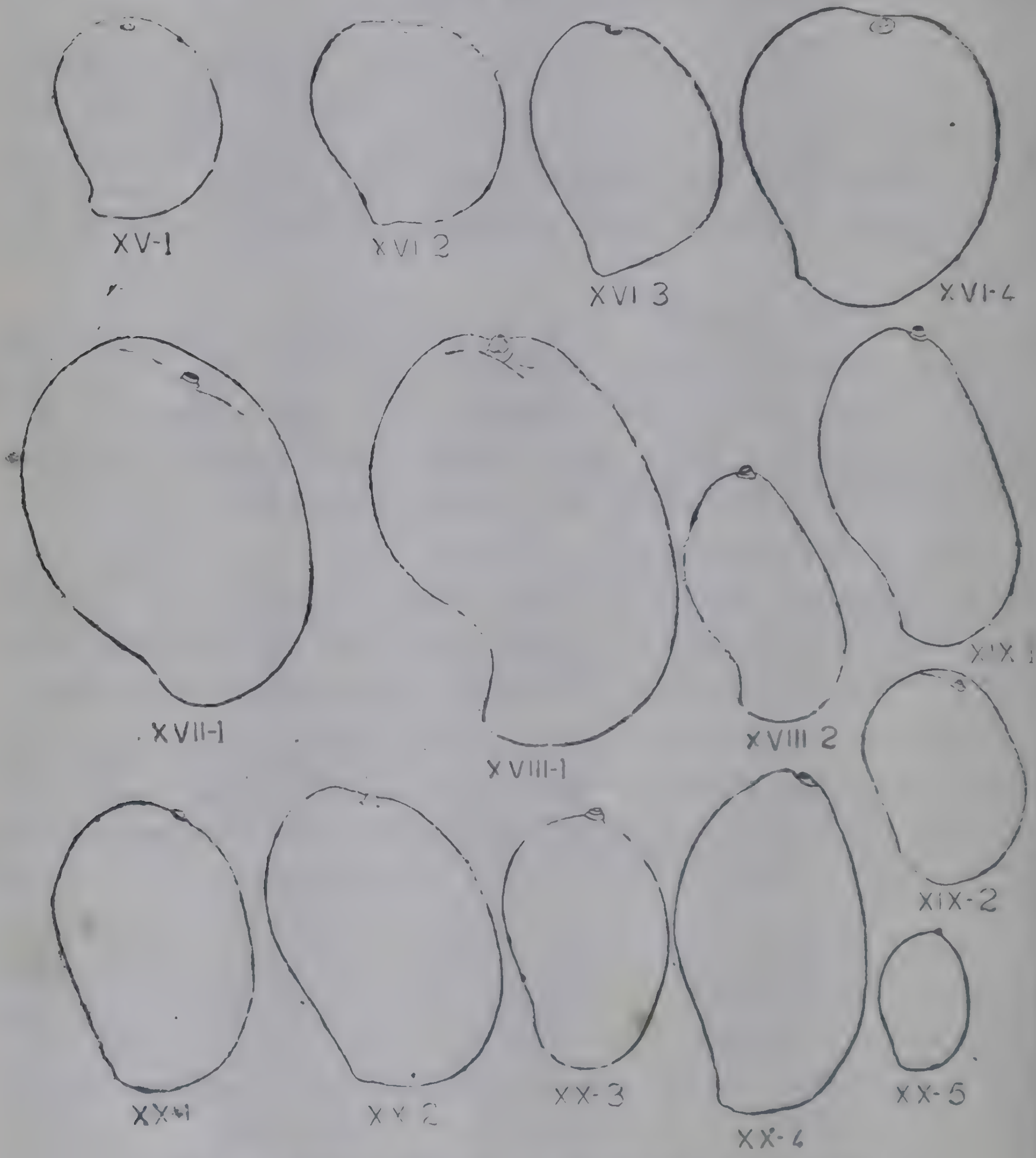


Fig. 34. Mango Sketches. (Khuddus to Chandrakaran.)
(Kalepad is missing in this Fig.)

fibrous, fairly juicy; eating quality good. Bearing heavy and in mid-season.

XIV - 2 - PANCHADARAKALASA:—Fruit medium and ovate, base slightly flattened, shoulders level, beak distinct, sinus absent, skin medium thick and yellowish; flesh soft and fibrous; juicy; eating quality good to very good. Bearing heavy and in mid-season. A popular juicy variety of the Circars.

XIV - 3 - SINDURA:—Fruit medium and ovate, base flattened, ventral shoulders slightly higher than the dorsal, beak distinct, sinus slight, skin medium thick and deep chrome coloured; flesh firm and fibreless, fairly juicy; eating quality good. Bearing medium and in mid-season. Keeps well.

XV - 1 - KHUDDUS:—Fruit small, ovate oblong to ovate, base rounded, shoulders level, beak mammiform, sinus shallow, skin medium thick and deep chrome coloured with a blush of coral red; flesh firm and fibreless; eating quality medium. Bearing medium and late. Keeps well.

XVI - 1 - KALEPAD (syn. KATTI NEELUM, KALAPADI):—Fruit small, ovate oblique, base obliquely rounded, ventral shoulder rising and then rounded, beak mammiform, sinus slight, skin smooth, medium thick, leathery and yellowish; flesh firm to meaty and fibreless; eating quality medium to good. Bearing heavy and in mid-season. Keeping quality good.

XVI - 2 - PETER (syn. YERRA GOVA, NADUSALAI, GRAPE, PETERPASAND, GOHABUNDER, PURI, RASPURI):—Fruit small and ovate, base slightly flattened, ventral shoulder broader and higher than the dorsal, beak broadly mammiform, sinus slight, skin medium thick, inclined to be rough and apricot yellow; flesh firm and fibreless, fairly juicy; eating quality good with a delightful flavour. Bearing heavy and in early season. Keeping quality poor to medium.

XVI - 3 - SALEM BANGALORA (syn. IRULAPPAN BANGALORA):—Fruit medium and ovate, base slightly flattened, shoulders level, beak broadly mammiform, sinus slight, skin medium thick and yellowish; flesh firm and fibreless, fairly juicy; eating quality very good. Bearing in mid-season and is medium. Keeps fairly well. This is a surprisingly little known variety among the choice varieties.

XVI - 4 - REDDIPASAND:—Fruit large and ovate, base slightly flattened, shoulders level, beak distinct, sinus shallow, skin medium thick and buff yellow ; flesh soft and fibreless ; eating quality good. Bearing medium and in mid-season.

XVII - 1 - BANGANPALLE (syn. BANESHAN, CHAPPATAI, BENGANPALLI):—Fruit large, obliquely oval, base obliquely flattened, ventral shoulder markedly broader and higher than the dorsal, beak a point to missing, sinus shallow, skin thin, smooth, shiny, membranous and yellowish ; flesh firm to meaty and fibreless ; eating quality good with a slight turpentine flavour which does not detract the value. Bearing heavy and in mid-season. Keeps well. This is a very popular variety of the Circars and Rayalaseema and is found to thrive in other parts of South India as well.

XVIII - 1 - JALAL SAHEB:—Fruit large, oblong, reniform, base rounded, shoulders level, beak absent, sinus deep, skin thick and yellowish ; flesh soft and fibreless and aromatic ; eating quality medium. Bearing medium and in late season.

XVIII - 2 - DONDAKAYALAMANU:—Fruit small and oblong, reniform, base rounded, shoulders level, beak absent, sinus shallow to deep, skin medium thick and yellowish ; flesh soft, deep chrome coloured and moderately fibrous, juicy ; eating quality good. Bearing heavy and in mid-season.

XIX - 1 - ACHARPASAND:—Fruit medium and obliquely oblong, base rounded, ventral shoulder broader than the dorsal, beak absent, sinus slight, skin medium thick and yellowish ; flesh firm and slightly fibrous ; eating quality poor as table fruit, but good for culinary purposes. Bearing heavy and in mid-season.

XIX - 2 - PORKAL:—Fruit small to medium, oblong oblique, base obliquely flattened, ventral shoulder broader and higher than the dorsal, beak a point, sinus slight, skin medium thick and apricot yellow ; flesh firm and fibreless ; eating quality good. Bearing medium and in mid-season. Keeps well.

XX - 1 - CHINNARASAM:—Fruit medium and oblong, base obliquely rounded, ventral shoulder broader and higher than the dorsal, beak a point, sinus absent or slight, skin medium thick and yellowish ; flesh soft, fibrous and very juicy ; eating quality medium to good. Bearing medium and in early or mid-season.

XX - 2 - CHERUKURASAM:—Fruit large and oblong oblique, base obliquely flattened, shoulders level, beak absent, sinus slight, skin medium thick and lemon coloured; flesh soft and slightly fibrous, juicy; eating quality very good. Bearing heavy, in clusters and in mid-season. A popular variety in the Circars.

XX - 3 - CALCUTTA BARAMASI:—Fruit medium and oblong oval, base rounded, shoulders level, beak absent, sinus slight, skin medium thick, leathery and apricot yellow; flesh soft and fibreless; eating quality good. Bearing medium to poor in mid and off-seasons.

XX - 4 - JAILOR:—Fruit large and oblong elliptic, base tapering, shoulders level, beak a point, sinus slight, skin medium thick and yellowish; flesh firm and fibreless; eating quality medium to good. Bearing medium and in mid-season.

XX - 5 - CHANDRAKARAN:—Fruit small and oblong, base rounded, shoulders level, beak and sinus absent, skin medium thick and yellowish; flesh soft and moderately fibrous; eating quality medium to good. Bearing heavy and in mid and early season. A polyembryonic variety.

XXI - 1 - JANARDHANAPASAND (syn. JANARDHANA PRASAD): —Fruit medium and oblong, base rounded and slightly extended, beak mammiform, shoulders level, sinus shallow, skin medium thick, leathery and yellowish with a strikingly attractive reddish blush in most parts; flesh firm and fibreless; eating quality medium to good. Bearing medium and in mid-season.

XXI - 2 - BANGALORA (syn. COLLECTOR, TOTAPURI, SUNDERSHA, BURMODEILLA, KILLI MOKKU, KALLAMAI, GILIKUKKU):—Fruit medium and oblong, base rounded, sinus shallow, skin thick, smooth and lemon chrome-coloured; flesh firm and fibreless; eating quality medium. Bearing heavy and in mid-season. Keeps well. A very regular cropping, commercial variety of Rayalaseema and the Circars and also grown extensively elsewhere.

XXI - 3 - KOLANKA GOA (syn. KOLANKA GOVA):—Fruit medium and oval, base rounded and slightly extended, beak outcurved, sinus slight to shallow, shoulders level, skin medium thick, tough, smooth and yellowish: flesh firm to crisp and fibreless; eating quality medium. Bearing heavy and in mid to late season.

XXII - 1 - PEDDA KALEPAD:—Fruit medium to large, oblong, base rounded, shoulders level, beak mammiform, sinus shallow, skin medium thick and yellowish ; flesh firm and fibreless ; eating quality medium to good. Bearing medium and in mid-season. Keeps well.

XXII - 2 - METTAVALSA PEECHUMANU:—Fruit medium and oblong oval, base rounded, ventral shoulder higher than the dorsal, beak distinct, sinus slight, skin membranous and light orange coloured ; flesh firm and very fibrous, juicy ; eating quality good. Bearing medium and early in the season.

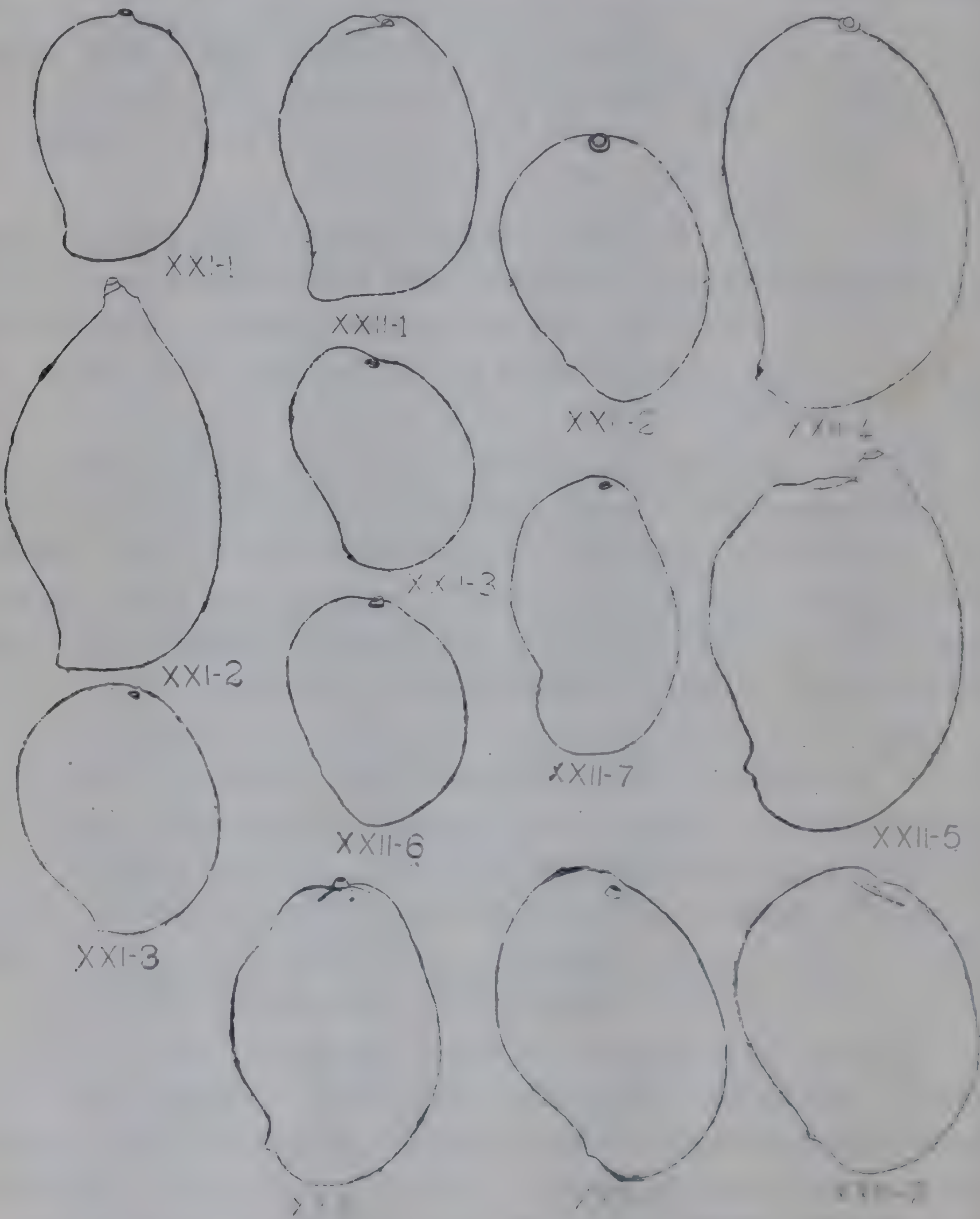


Fig. 35. Mango Sketches. (Janardhanapasand to Alampur Baneshan.)

XXII - 3 - PANAKALU:—Fruit medium and oblong oblique, base obliquely flattened, ventral shoulder higher than the dorsal, beak distinct, sinus slight to shallow, skin medium thick and deep chrome coloured ; flesh firm and moderately fibrous, juicy ; eating quality good with delightful flavour. Bearing medium.

XXII - 4 - PEDDARASAM:—Fruit large and oblong, base rounded, ventral shoulder slightly higher than the dorsal, beak mammiform, sinus shallow, skin medium thick and yellowish ; flesh soft and densely fibrous, juicy ; eating quality fairly good. Bearing medium and in mid-season. Keeps well.

XXII - 5 - SAFED AMINI:—Fruit large and oblong oval, base rounded and extended, shoulders level, beak prominent, sinus shallow, skin thin and yellowish ; flesh firm and fibreless ; eating quality good. Bearing medium and in mid-season.

XXII - 6 - RAJUMANU:—Fruit medium and oblong oblique, base obliquely flattened, ventral shoulder higher than the dorsal, beak prominent, sinus absent, skin thin and yellowish ; flesh soft and moderately fibrous ; eating quality good. Bearing heavy and early in the season.

XXII - 7 - NAGULAPALLI IRSALA:—Fruit small and oblong reniform, base rounded, shoulders level, beak slight but distinct, sinus deep, skin thin and yellowish; flesh fibreless and soft, juicy ; eating quality good. Bearing heavy and in mid-season.

XXIII - 1 - YERRA AYODYA:—Fruit large and oblong, base rounded, beak distinct, shoulders level, sinus shallow, skin medium thick and yellowish ; flesh firm and fibreless ; eating quality good. Bearing medium to poor, in mid-season. Keeps well.

XXIII - 2 - HIMAYUDDIN (syn. IMAMPASAND, HIMAMPASAND):—Fruit large and obliquely oval, base obliquely flattened, ventral shoulder higher than the dorsal, beak distinct, sinus absent, skin medium thick and yellowish ; flesh firm and fibreless ; eating quality very good. Bearing poor to medium and in mid-season. Keeps well. This is undoubtedly one of the first rate mangoes of South India.

XXIII - 3 - ALAMPUR BANESHAN:—Fruit large and oval oblique, base obliquely flattened, ventral shoulder higher than the dorsal, beak slight but distinct, sinus slight, skin thin, membranous and yellowish ; flesh firm and fibreless ; eating quality very good.

Bearing medium and in mid-season. Keeps well. With Jehangir and Himayuddin this variety is ranked among the best table mangoes of South India.

XXIV - 1 - AMLET (syn. MANORANJANI, HAMLET):—Fruit large and ovate reniform, base slightly flattened, shoulders level, beak prominent, sinus shallow, skin medium thick and yellowish, with a reddish blush ; flesh soft and fibreless ; quality medium to good. Bearing medium to poor.

XXIV - 2 - DOPHALA:—Fruit medium and obliquely oval, base rounded, ventral shoulder higher than the dorsal, beak distinct, sinus slight, skin medium thick and yellowish ; flesh soft and fibrous ; quality medium to good. Bearing medium and in mid and off-seasons. Keeping quality good.

XXIV - 3 - PEEDA NEELUM:—Fruit medium and oblong reniform, base rounded, shoulders level, beak mammiform, sinus deep, skin medium thick and light orange in colour, flesh firm and fibreless, quality medium to good. Bearing medium and in mid-season. Keeps well.

XXIV - 4 - PADIRI:—Fruit medium and oblong, base rounded, shoulders level, beak distinct, sinus shallow to slight, skin medium thick, leathery and yellowish with a blush of coral red : flesh firm and fibreless ; quality good to very good. Bearing medium and in mid-season. Keeping quality good. This is a variety of some repute in parts of Tamilnad, especially in Tanjore district.

In addition to the above varieties under general cultivation, the following chance seedlings and hybrid progenies have been selected at the Fruit Research Station, Kodur as very promising and worthy of popularisation.

(1) K. O. 7/5 :—This is a cross between Himayuddin male and Neelum female parents. Tree has rounded top, leaves out-held, oval lanceolate, slightly reflexed, folded and with subacuminate tip : fruit medium to large, oblong to oblong oval, base rounded with slight extension at the stalk end, shoulders level, beak slightly prominent and mammiform, sinus slight to shallow, skin medium thick, leathery and yellowish ; flesh firm and fibreless ; quality very good. Bearing heavy in mid to late season. Keeps well.

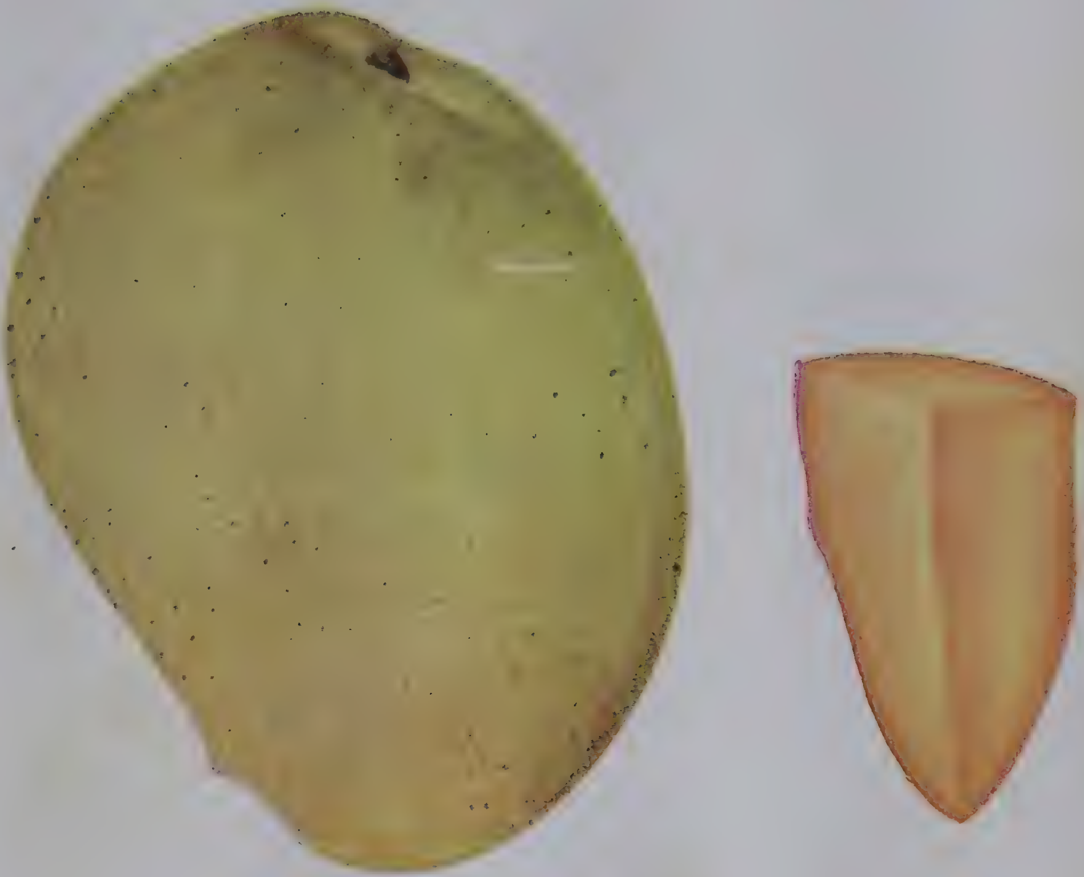


PLATE II. ALAMPUR BANESHAN

(To face page 140)

(2) K. O. 9/3 :—This is also a cross between Himayuddin male and Neelum female parents. Tree is similar to K. O. 7/5 except that leaves have acute tip. Fruit is medium to small, ovate oblique, base obliquely flattened to rounded, ventral shoulder higher than the dorsal, beak a point, sinus slight to absent, skin smooth, medium thick, leathery and yellowish ; flesh firm and fibreless ; quality very good. Bearing capacity is not yet fully determined, but fruits ready in mid-season.

(3) K. O. 11/13 :—This is a cross between Jehangir male and Suvarnarekha female parent. Tree has rounded top, with out-held leaves which are slightly reflexed, flat, oval lanceolate and with sub-acuminate tip. Fruit is large and ovate oblong, base rounded with a slight extension at the stalk end, shoulders level, beak distinct, sinus slight, skin thick, tough, inclined to be rough and yellowish ; flesh soft and fibreless ; quality good. Bearing medium to heavy, in mid to late season.

(4) K. O. 11 :—This is a chance seedling from an unknown parent. Tree has rounded top with out-held leaves, which are slightly reflexed, oval lanceolate, flat with sub-acuminate tip. Fruit is large and ovate, base rounded with a slight extension at the stalk end, shoulders level, beak slightly prominent, sinus slight, skin roughened to slightly warty, and yellowish, flushed with coral red ; flesh soft and fibreless ; quality very good. Bearing medium to heavy, in mid-season.

(5) K. O. 22 :—This is a chance seedling of Dilpasand. Tree resembles K. O. 11, excepting that it has leaves with acute tip. Fruit is medium and ovate oblique, base obliquely flattened, ventral shoulder higher than the dorsal, beak distinct, sinus slight to shallow, skin medium thick, smooth, leathery and yellowish ; flesh firm to soft, slightly fibrous ; quality very good. Bearing medium and in mid-season.

Neither the list of varieties nor the descriptions given above can be termed as sufficiently comprehensive to suit every type of readers. For a more complete key to South Indian mango varietal situation, attention is invited to the Monograph on Classification and Nomenclature of South Indian Mangoes, published by the Madras Department of Agriculture.

VARIETAL SELECTION

The excessive preference among the South Indian mango growers for a collection of very large number of varieties has resulted in veritable plant museums of little economic importance. A potent means of improvement lies therefore in the restriction of the number of varieties to very few most dependable croppers and to those that possess the greatest market value and are largely in demand. Connected with this is the top-working of inferior varieties which are believed to preponderate in most of the existing orchards. In this respect the varieties introduced from other parts of the country, excluding those from Ceylon, are usually the poorest performers. In a collection stocked with over 100 varieties at the Fruit Research Station, Kodur, no less than 20 varieties failed to give any harvests till the eighth year after planting, and all these represented those introduced from Central and Northern India. The South Indian varieties on the other hand, commenced to bear crops from about the third year of planting, the maximum individual tree yield of one of the latter varieties being 3,355 fruits weighing 487 lbs., while another gave 984 fruits weighing 641 lbs. That most of the varieties in South Indian commercial orchards constitute nothing more than mere curiosities, is also clear from a detailed performance study undertaken by the author over a period of four years in an orchard planted to 1,632 bearing trees of 25 different varieties near Kodur. This orchard passes off as one of the remunerative orchards, and yet it was revealed from the study that Neelum and Bangalora were the only varieties that could be deemed worthy of extensive cultivation out of those planted in this particular orchard. In the interest of orchard efficiency, therefore, the multiplicity of varieties that now prevails must give place to a limited number of profitable horticultural entities in our future orchard establishments.

This leads to the question—which are the profitable varieties for each region? It has to be confessed that a straight answer to this is yet not possible. It can only be furnished from the results of the variety trials in each region; and these trials are yet to be done in all the representative regions of South India. From a survey of this part of India and as a result of sifting of the views of the commercial growers, it seems possible to prepare an interim list of varieties suitable for each region, and this is presented below.

CIRCARS :—Suvarnarekha, Baneshan, Cherukurasam, Rajumanu, Firangiludwa, Kothapalli Kobbari, Panchadarakalasa, Desavalthiyamamidi, Sannakulu, Dondakayalamanu, and Nagulapalli Irsala.

RAYALASEEMA :—Rumani, Neelum, Suvarnarekha, Baneshan, Acharpasand, Cherukurasam, Bangalora, Alampur Baneshan, K. O. 7/5 and K. O. 11.

CENTRAL DISTRICTS:—Alphonso, Peter, Salem Bangalora, Rumani and Baneshan.

WEST COAST, COORG AND PARTS OF MYSORE :—Mundappa, Neelum, Taripadi, Alphonso, Olour, Bennet Alphonso, Kalepad, Peter and Chandrakaran.

TAMILNAD :—Padiri, Alphonso, Peter, Neelum, Bangalora, Baneshan, and clonal selections of off-season bearing varieties.

There is a fancy among the mango growers in the region to plant varieties that go under the name of *Baramasis* which are popularly believed to be regular off-season croppers. None of these so called *Baramasis* have proved to be dependable off-season croppers and of superior fruit quality. Owing to the peculiar seasonal conditions in parts of Tamilnad, especially near Tenkasi in Tinnevelly district, several varieties grown there are in a position to give sizeable off-season crops. At Kodur observations have revealed that in 1940-'41 Ambalavi, a variety from Ceylon produced five blossom crops in September-October, December, January-February, March-April and May-June. Neelum, Kintalvanipeta, Manoranjan, and Willard produced three crops of blossoms each, and 28 other varieties gave two crops of flowers each from January to March. Peter and Baneshan have often been found to produce off-season blooms in Coimbatore and to a much greater extent near Tenkasi. An off-season bearing tree located at Tenali in Guntur District when reproduced by inarching, produced off-season flowers in the progenies also in the same district. Both seasonal influences and varietal peculiarities seem to play therefore an important factor in off-season crop production. Although Olour and other West Coast varieties can be harvested in some years even as early as February, these cannot be called strictly as off-season croppers, they being instrumental in mainly extending the main bearing season.

PROPAGATION

Since seed propagation does not ensure the availability of trees true to the parent, except in the case of few polyembryonic races, the propagation of superior varieties and trees of mango has to be done through vegetative means such as by cuttings, layerings, gooty, budding and grafting. It has been found possible to raise a few plants by cuttings at Kodur by cincturing the one-year-old shoots and planting out in beds the part above the cinctured region after the callus formation is well advanced, in the form of 8 to 10 inches long hard wood cuttings. Layering and gooty are also possible, especially if the operations are done under high humid atmospheric conditions. None of these three methods, however, is of any value in commercial nursery practice, as the success is extremely low. Budding and grafting methods have therefore held the popular fancy in mango propagation all over the mango producing centres of the world.

Raising of seedlings is a necessary preliminary step for the employment of all kinds of budding and grafting methods. The seeds or stones are extracted from ripe and sound fruits and are sown immediately in seed beds or pots. In large scale nurseries it is usual to collect the stones from the consuming centres in the harvest seasons and then sow them. Sometimes such seeds are merely heaped together with some soil thrown over them. In the monsoon period most seeds germinate in the heap, and the seedlings are then lifted and transplanted to beds or more generally to pots. In the larger mango growing centres there is also a practice of collecting the naturally or spontaneously grown seedlings from the seeds of tree-dropped fruits or from the seeds which were cast off after fruit consumption. This practice has been found much cheaper in some areas than the raising of seedlings from seeds specially extracted for sowing. At Taliparamba the cost of raising seedlings in beds with the spontaneously sprouted stones or of young seedlings collected in the vicinity has worked out to Rs. 3-5-0 only per thousand seedlings in 1946-'47, as against Rs. 22-7-3 for the same number raised by sowing directly in beds in the same year. However, the pace of growth and plant vigour are markedly better in plants raised from the extracted seeds and sown with care than by other methods. The former also produce seedlings with a large proportion of straight stems and tap roots, both of which features are essential for success in vegetative propagation. Crooked stems and tap roots are the necessary accompaniments of growth in ill-prepared or unsuitable soil media, since the seedling in its initial process of emergence through the soil is compelled to make a detour when the least impediment occurs by way of gravel or other solid material in the soil above the seed. Sometimes such obstructions in the path of growth of the seedlings result in the formation of a loop on the stem, rendering the plants unfit for use as a rootstock. The maintenance of a good soil tilth in beds or pots is therefore necessary, and this can only be provided in a properly maintained nursery where sowing is restricted to sound seed material, rather than to the transplanting of spontaneously grown plants in diverse media and surroundings.

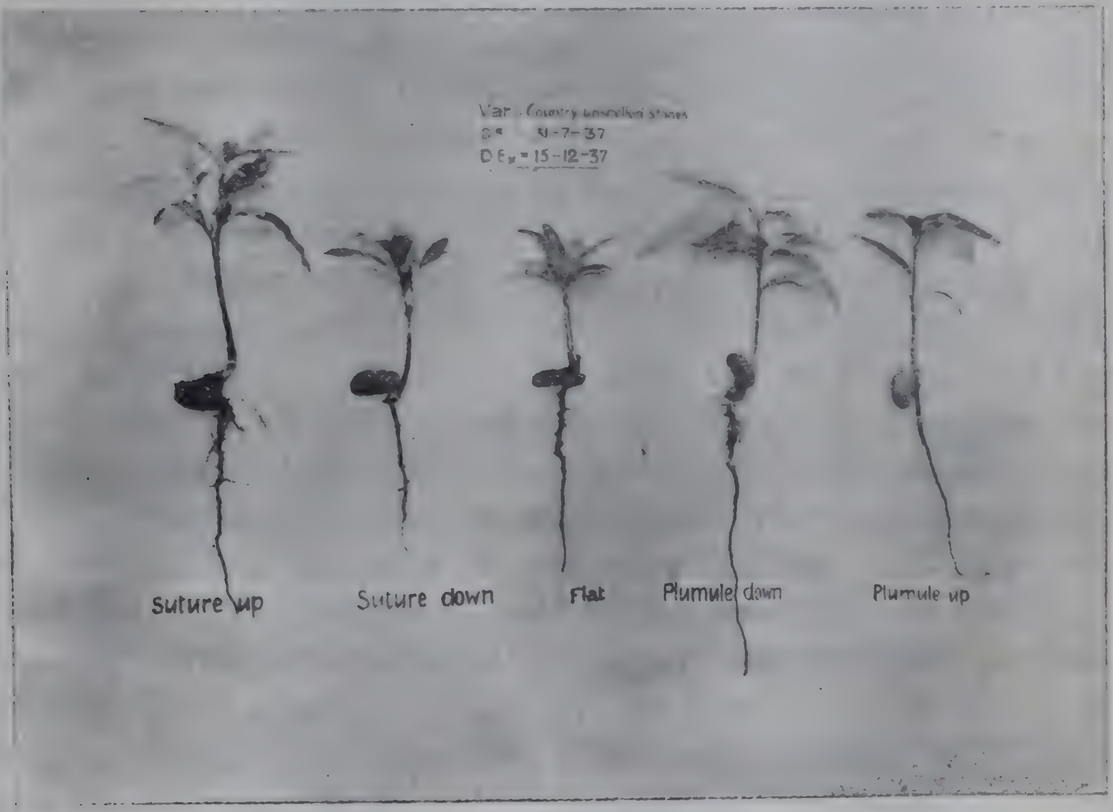


Fig. 36. Sowing Mango seeds by five methods.

The best methods of sowing have been determined at Kodur by experimentation. Sowing the seed with plumule pointing upwards has been found to produce a straight tap root and stem, both of which facilitate vegetative propagation. Shelling the stones before sowing was also found to produce similar results, but in this case the germination percentage was very much lower than in unshelled stones, besides the higher cost on shelling operation. The common method of sowing the seed flat is not conducive for the formation of maximum number of straight stemmed and tap-rooted seedlings. Shelling the stones offers, however, certain advantages, in that it leads to an effective elimination of diseased or worm infested kernels and also results in an earlier germination, on an average by twelve days. Despite these benefits, it is doubtful if the nursery trade in India will resort to shelling on a commercial scale, in view of the expensiveness of the operation and the plentiful supply of stones available in the producing areas in the harvest season.

Grading of fruit or stones cannot be classed as a necessary operation in so far as the mango is concerned. In a trial conducted at Kodur it was found that large sized fruits have failed to give invariably a uniformly high germination percentage. The smallest sized stones did produce the lowest germination percentage, but the difference between such and larger sized stones was not by any means larger than that noticed between seed parents. Selection of seed parents is therefore of obviously greater importance—a fact which has been confirmed by repeated trials at Kodur. These have established that a considerable time and expenditure can be saved if the nurserymen select the best seed parent in their respective regions on the basis of actual tests. Seedlings from some seed parents were found to become ready for inarching within nine months of sowing, while others took at least three months more to attain similar stage. In a subsequent page will also be shown how the seedlings of polyembryonic seed parents have induced better tree development in the orchard than those of monoembryonic seed parents. Although the selection of the best seed parents for each cultivated variety in each region is yet to be determined, it will be well for the larger nurserymen to pay some attention to this aspect of the question, so as to secure on the basis of their own observations over a period of years the necessary information on the growth of seedlings from each of the seed parents that are available to them.

Since the growth of seedlings is slower in pots than in beds, it is preferable to sow the seeds first in the ground and then shift the seedlings to the pots at a later stage. Some recommend that the sowing should be done direct in the site, where the grafted or budded tree is to grow finally. This is an expensive process, involving the maintenance of seedlings spread out over a much larger area than in beds and cannot therefore have an appeal to commercial mango growers.

A proportion of mango stones is often found unfit for sowing. Thin, papery stones with no kernel are specially common in off-seasons, and may also be due to lack of pollination in normal seasons. All such stones should be sorted out prior to the sowing operation.

When sown in beds, a spacing of nine inches from seed to seed in the row and about 18 inches between the rows is usually adopted. This system provides convenience in the subsequent operation of lifting the seedling as well as for the weeding of the beds. The seeds germinate in about 25 days of sowing giving over 80 per cent. germination in most cases, and the plants can be lifted out for potting in five to six months. Further delay in lifting has been found to lead to a higher mortality in lifted seedlings. The polyembryonic mangoes generally produce a lower germination, not exceeding 70 per cent, and most giving much less ; but they possess the advantage of producing two to five or even more seedlings per seed. Bellary, Chandrakaran and Mylepelian varieties have been found to germinate better than other polyembryonic races, while Kurkan was found to produce the largest number of seedlings per seed. At Taliparamba, however, it was noted that in 1946-'47 some polyembryonic mangoes like Bappakai and Olour gave a germination percentage of 57 and 25 per cent. respectively with a mean of 1.6 seedlings in each germinated seed. It was also reported that the seedlings of Bappakai with larger cotyledons and which emerged first, were more vigorous than the seedlings which emerged later and had smaller cotyledons.

It is a common practice to retain a ball of earth around the roots of mango seedlings at the time of lifting out from the beds for their transplantation. In some very sandy areas, nurserymen also practice the method of lifting the seedlings with naked roots in the rainy season for potting, without any marked ill-effects. Trials at Kodur have revealed that with care and in a suitable season, such a system can be adopted in other parts of South India as well. In January 1937 a batch of 129 seedlings of about six months of age when lifted with naked roots gave a percentage survival of 82.9, as against 86.9 per cent. survival in batches lifted at the time with balls of earth around the roots. In both the batches the roots were shortened to about nine inches from the ground level and the seedlings were transplanted into beds under dense shade. These lead to the view that exposure of roots for a short duration at the time of transplanting is not detrimental to the life of mango seedlings, at least in certain seasons under South Indian conditions. If the seedlings are to be retained in beds for more than about six months, and the lifting is to be done during hot and dry spells, removal of a majority of leaves about a week prior to lifting may be useful to reduce mortality. Whatever the season and method of lifting may be, the seedlings should be potted immediately they are removed from the beds.

The size of pot may vary from six to nine inches diameter at the broadest end. Although earthen pots are largely employed in most parts of South India, hill grass, cocoanut coir, cocoanut husk, and bamboo containers are also sometimes employed in the West Coast. The bamboo chip baskets are usually made in the form of earthen pots, but some use whole bamboo poles cut into pieces of 9" to 12" length and split into two equal sized longitudinal halves, which are bound together by wire or strong rope. Cocoanut husk, coir or hill grass twists made into a receptacle are in use where these materials can be had cheaply. A trial at the Fruit Research Sub-Station, Taliparamba has shown that hill grass containers are about 50 per cent. more expensive than cocoanut husk containers. The latter also resist white ant attack and provide better drainage and better penetration of moisture to the root, and enable the containers to be used more than once, on account of their greater resistance to water and weather conditions than the hill grass containers.

The ingredients commonly used to fill the pots are made up of an equal quantity of good garden loamy soil, well-rotted cattle manure, and clean sand. Instead of cattle manure, leaf mould, prepared by storing dry and fallen leaves for about one year in covered pits with soil thrown over them, and letting them to be transformed there into a powdery form, can also be used. Every earthen or solid bamboo pot or container should have one or two holes at the bottom or on the sides near the lower edge for drainage of surplus water. If the holes on the sides are fairly large and function well, they are superior to the holes at the bottom, since the tap root is liable to penetrate through the latter. The holes should be loosely covered with a few crocks or broken pieces of earthen pots, superimposed by a thin layer of coarse sand or gravel, over which the ingredients suggested above are to be placed. When the seedling is lifted from the bed, it is brought near the pot and placed in the centre of the pot in a hole made by hand inside in the mixture. Unless the tap root is cut to about nine inches and the pot is at least ten inches high, the seedling cannot be easily accommodated. The widespread practice of crumpling the tap root inside the pot has no advantage associated with it. On the other hand, the surplus root portion retained in the pot may hamper the proper formation and development of laterals and may even lead to the rotting of portions of the root system damaged in the course of the forceful jamming of the large root system inside a small container. After the plant is set straight in the centre, the soil or soil mixture should be pressed all around evenly and firmly, and the potted plant should be watered with a can carefully so as not to dislodge the soil.

The potted seedlings are usually kept in complete or partial shade until required for grafting. The side grafting and budding are done in nurseries in beds, for which purpose the seedlings are either retained in the beds or are transplanted preferably to new beds adopting a spacing of about 12 inches in the row and 18 to 24 inches between the rows. In these cases also, small holes have to be dug out in the new well-tilled beds either with a hand tool or with a nursery transplanter. After the lifted seedlings are placed in these pits soil has to be firmly pressed all around, and the beds irrigated immediately. As these plants have to remain in the open, unlike the potted plants, it is desirable to choose a cloudy and cool day for lifting and transplanting operations and to restrict them to the evenings rather than to warmer parts of the day.

For economic maintenance of potted seedlings, a trench of nine to twelve inches depth and as long and wide as is found necessary, is recommended. If the pots are placed erect and close together in these trenches and the interspaces are covered with dry leaves, and water let into the trenches up to the top edges of the pots once in five to seven days during dry periods, a great deal of economy in watering of the plants will result. Otherwise and when placed on the ground, the potted plants have to be hand watered daily during dry weather. Some advise the occasional application of a dilute cow dung solution with or without a small quantity of ammonium sulphate added to it, in order to stimulate growth in the seedlings.

The potted seedlings can be used for grafting at any time after about a month of potting. As a matter of fact, even younger seedlings of even less than three months of age can be used for grafting. In commercial nursery practice, however, 12 to 18 months old seedlings are very largely preferred. This means that the seedlings have to remain in the pot for six months to one year after potting.

The age of seedling for grafting has been a subject of some controversy. A fairly elaborate trial with Neelum grafts on rootstocks of three different age groups has disclosed at Kodur that the popular belief that, the older the rootstocks the greater the size of the grafts or better the orchard performance, is not based on facts, at least with grafts prepared on seedlings of 10½ to 16½ months of age. The larger size of grafts is partly dependent on the size of the scion shoots and partly on the size of the rootstock. To meet the demand for large grafts, nurserymen sometimes employ seedlings of three or more years of age. Such grafts travel poorly and establish with difficulty on some sites. Experience as well as research findings seem to suggest that under the South Indian conditions, grafts of mango on seedlings of 12 to 18 months of age are suitable. Expectations of an earlier bearing or more profit on larger or older grafts are likely to prove illusory.

For the purpose of inarching the pot containing the seedling is brought near the scion tree, which is desired to be multiplied. Some nurserymen prune their scion trees severely to produce low-headed trees with a large profusion of scion shoots close to the ground. This enables the potted seedlings to be placed on the ground for inarching to such low-hanging scion shoots. This system of raising a special batch of scion trees by severe heading-back seems questionable, if only because it does not enable the purchaser to find out the normal bearing capacity of the scion parent. Even the nurseryman is liable to make errors in the identification of his varieties, which rarely are able to set a crop, with the result that the purchaser of grafts is exposed to the risk of securing plants different from those he intends to have.

In places where scion trees are not specially trained for the purpose, the potted seedlings are either tied to a strong limb close to the scion shoot and in a position that will enable the inarching to be done with ease and with safety to the graft-union, or placed on a platform or other structure specially erected for the purpose. A grafting pot stand of the type devised at Kodur can also be used to hold the potted seedling, but this is likely to prove expensive for large scale commercial nursery use.

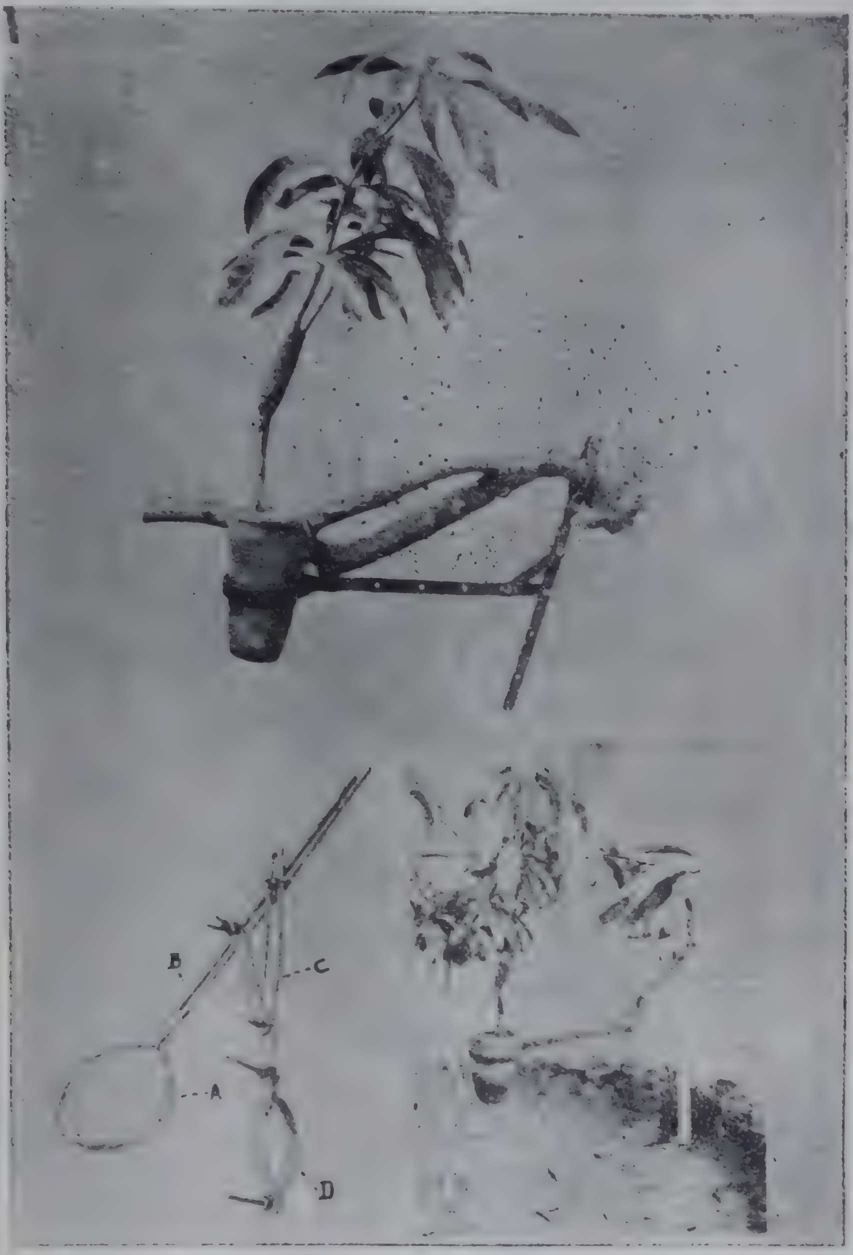


Fig. 37. Grafting with the aid of grafting pot stand.

The actual process of inarching with the mango consists of removal of a strip of bark, two and a half to three inches long with a small layer of wood attached to it, from the potted seedling at a height of nine to twelve inches from soil surface in the pot. A similar strip is then removed from the scion shoot selected for inarching. This shoot should be healthy with well developed foliage, and of the same thickness at the place to be marked for the removal of bark for inarching as that of the seedlings. Care is taken to ensure that the two exposed surfaces on the seedlings and the scion shoot fit together securely, leaving no gap when the two treated shoots are held together by hand with the exposed parts in contact with each other. In this position they are tied firmly with raffia, banana fibre or country twine. Some prefer to place strips of dried banana sheaths on the shoots before tying, with the hope that it will prevent the constriction on the shoots from the tying by fibre or string. Cloth strips dipped in melted paraffin or fibre of sann hemp or *Ficus* are also used as tying material in some places. Many persons apply over the bandaged portion a poultice made of equal parts of clay or red soil, cow dung and sand mixed with sufficient water to make a thick paste. At Taliparamba, banana fibre bandage covered over with a mixture of clay and cow dung was found to be the most economical in a trial conducted in 1946. When banana fibre was covered over with layer of banana sheath and finally bound over with banana fibre, it was found that the banana sheath layer rotted during the monsoons, and attracted fungal and insect attack.

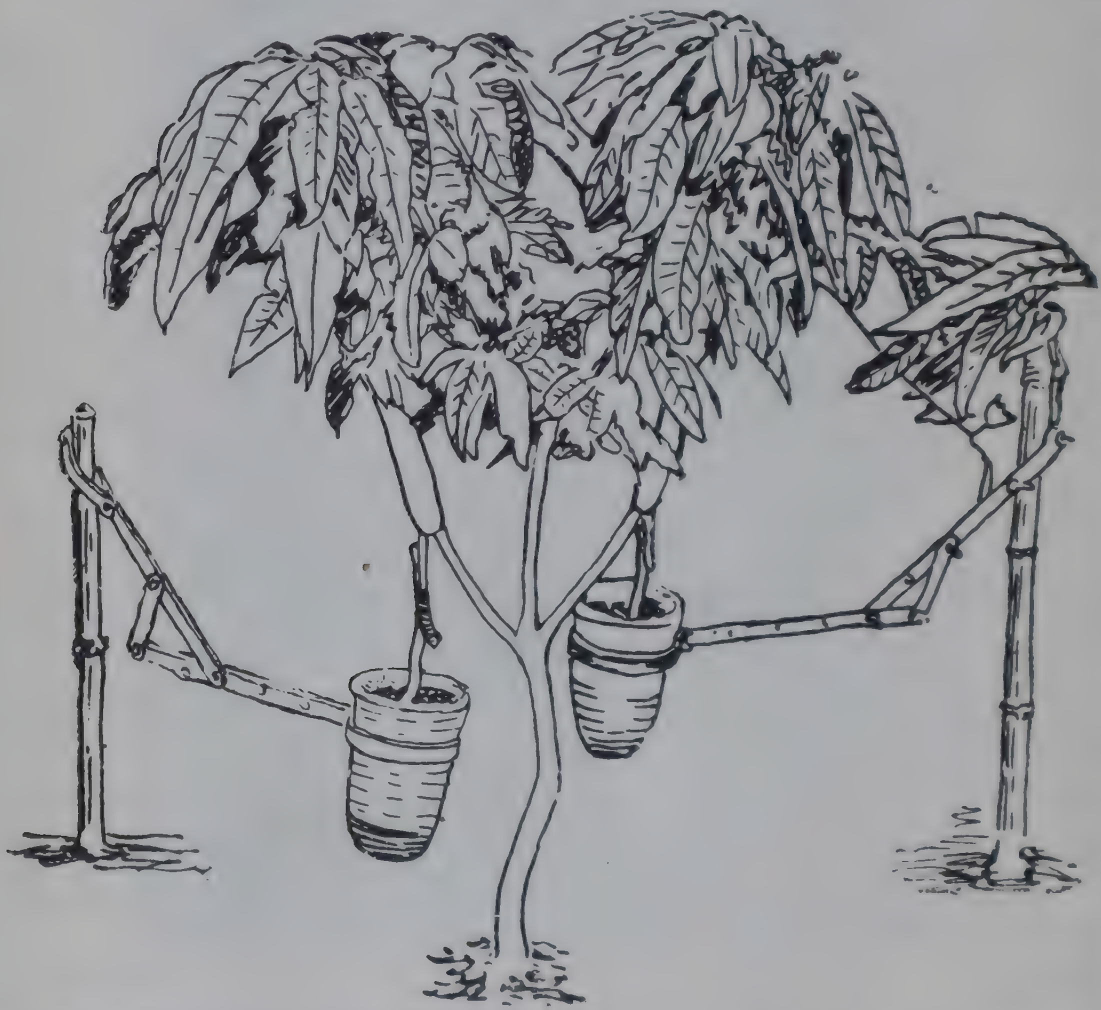
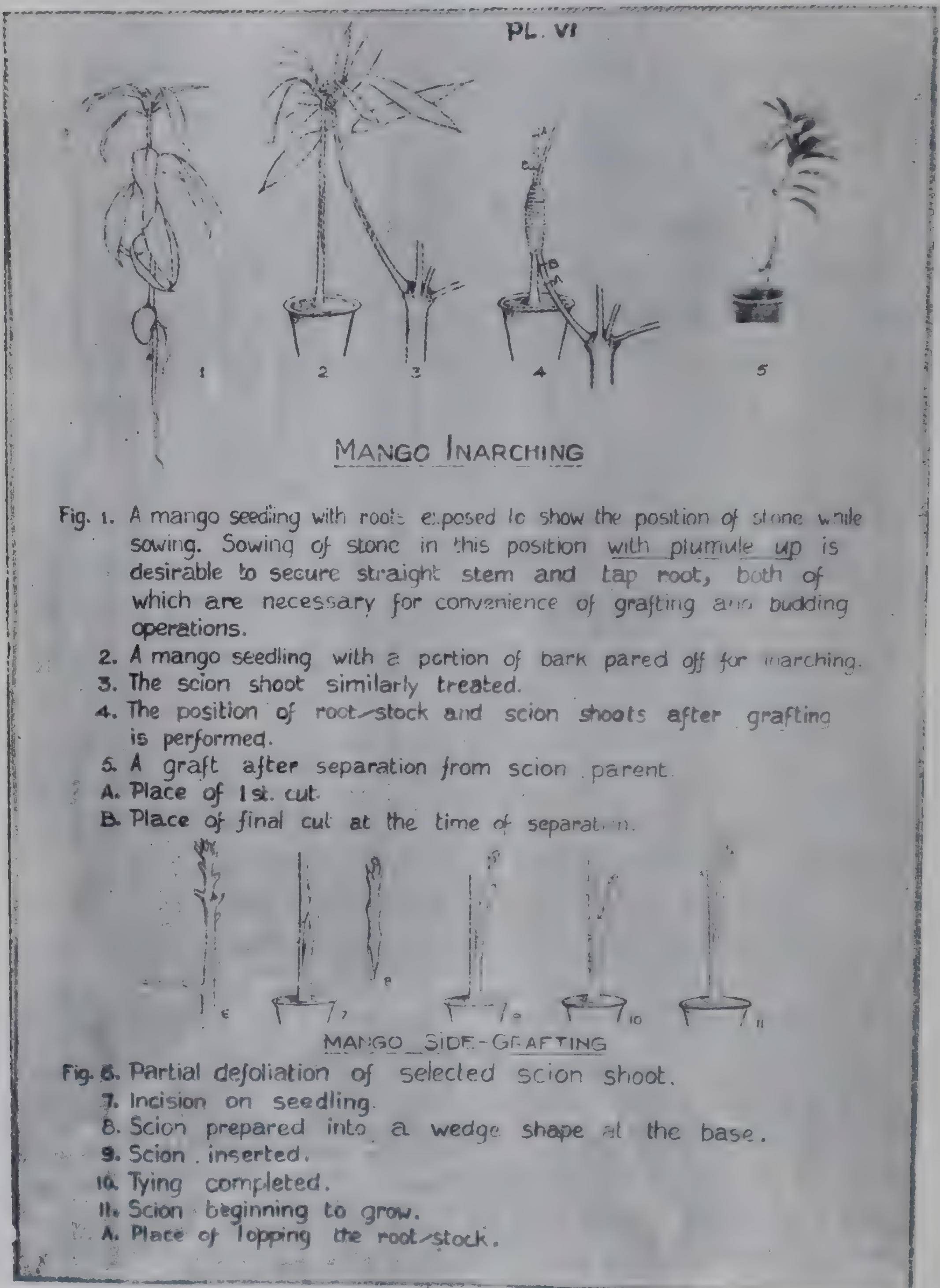


Fig. 38. Grafting with the aid of grafting pot stands. (Another illustration.)

In about 30 to 60 days after the operation, depending mainly on the season and partly on the scion varieties, a cut half-way through is made with a sharp knife just above the grafted region on the rootstock seedling and just below that on the scion shoot. A similar cut is made a fortnight or a month later a little above or below the previous cuts. Some people prefer to deepen the original cuts to two-thirds or three-fourths through, while some others do not believe in giving the second cut at all. In another fortnight or a month, the cuts may be extended to entirely separate out the scion shoot from the scion parent, as well as to remove the seedling top. The separated graft may be removed and placed in partial or complete shade for one to two months before sale or planting out in the final site. About a month to three months after separation of the graft, the mud poultice and the rest of the bandages over or around the graft-joint have to be removed. Throughout the period from the date of inarching to that of planting out in the orchard, watering the potted plants has to be regularly attended to. This watering may be done daily in dry periods, if the potted seedling is inarched above the ground. If it is placed on the ground and buried in soil for stability or for economy in irrigation, watering may be done to the soil around the pot less frequently, the interval depending upon the speed with which the soil becomes dry.

The optimum period for inarching has been determined at Kodur by elaborate trials, and this was found to be July to September in 1936, with October to December ranking next in importance in the same year. June was found to be the worst month. These obviously cannot hold good all over South India, in view of the fact that variations in weather conditions from year to year and between places largely determine the suitability or otherwise of a month for inarching. Trials at Taliparamba have for instance showed that the highest success was achieved there in 1946 during the months of July, August and September, which also have proved to be the most economical for large scale production of mango grafts. Varietal responses may also vary in different seasons, as they do vary both in regard to the degree of success by inarching as well as the length of time required for the separation from the scion parent. Age of rootstock seedling, its condition, as well the manipulative skill of the person performing the inarching operation, may also contribute to the final success. As a general rule, however, July to February may be taken as a suitable period for inarching mangoes in most parts of South India. A hot and dry period, as well as heavy rains during the inarching period are not conducive for success. Between varieties, Neelum has been found at Kodur to give a higher percentage of success than Bangalora, while Rumani has been found to require about a month more between inarching and separation than Neelum.



MANGO INARCHING

Fig. 1. A mango seedling with roots exposed to show the position of stone while sowing. Sowing of stone in this position with plumule up is desirable to secure straight stem and tap root, both of which are necessary for convenience of grafting and budding operations.
2. A mango seedling with a portion of bark pared off for inarching.
3. The scion shoot similarly treated.
4. The position of root-stock and scion shoots after grafting is performed.
5. A graft after separation from scion parent.
A. Place of 1st. cut.
B. Place of final cut at the time of separation.

MANGO SIDE-GRAFTING

Fig. 6. Partial defoliation of selected scion shoot.
7. Incision on seedling.
8. Scion prepared into a wedge shape at the base.
9. Scion inserted.
10. Tying completed.
11. Scion beginning to grow.
A. Place of lopping the root-stock.

Fig. 39. Mango inarching and side grafting.

The inarching of mango is so popular in South India that any other method is not likely to appeal to growers or nurserymen, unless the success by the new method or its other advantages are demonstrated beyond any shadow of doubt. Inarching is undoubtedly a very tedious method involving several operations like potting, erection of platforms for potted seedlings and daily hand watering of the potted plants, particularly when they are placed at different heights for the inarching operation. For the sake of economy it also renders necessary the establishment of the scion tree plantation very close to the seed bed or pot yard. All these handicaps and incidental operations associated with mango inarching can be got over if budding or other grafting methods, which permit the severance of the scion shoot before its insertion or grafting to the seedling rootstock, can be successfully employed. From a trial of all known methods of vegetative propagation at Kodur, it is now possible to state that three different methods of budding and one method of side grafting are worthy of adoption in South Indian mango nurseries. Each of these methods is briefly described below.

Flap Budding:—A transverse incision is made (Fig. 41) in the bark of the seedling as far as the wood, and the bark is then peeled down carefully to a length of about one and a half inches. The bud-shield is then removed from the scion shoot with a small piece of wood attached to it, and this is pushed under the flap till the exposed edges of rootstock rind and the bud-shield are in perfect contact. The flap is then brought to position so as to

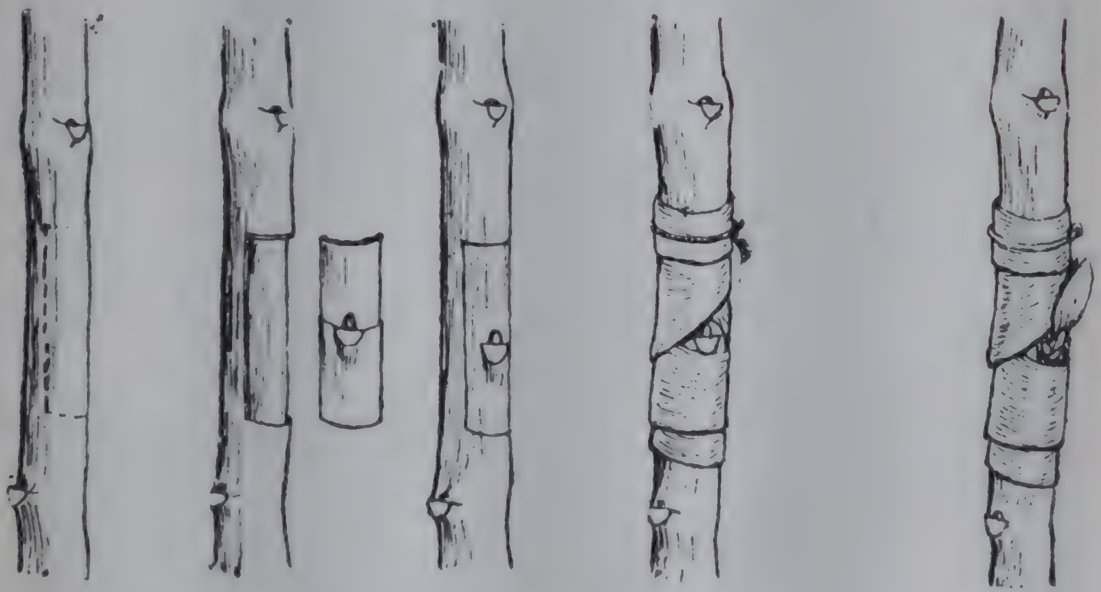


Fig. 40. Patch budding.

cover the bud-shield completely, and is then wrapped around with paraffined cloth or raffia fibre, and finally by pieces of dried banana sheaths. About a month later the bandages are removed, and the overlapping flap of bark is cut off. If the buds are green then, the rootstock seedling is ringed about an inch wide and about two inches above the point of insertion. The removal of bark in the form of a ring is done to stimulate growth of the

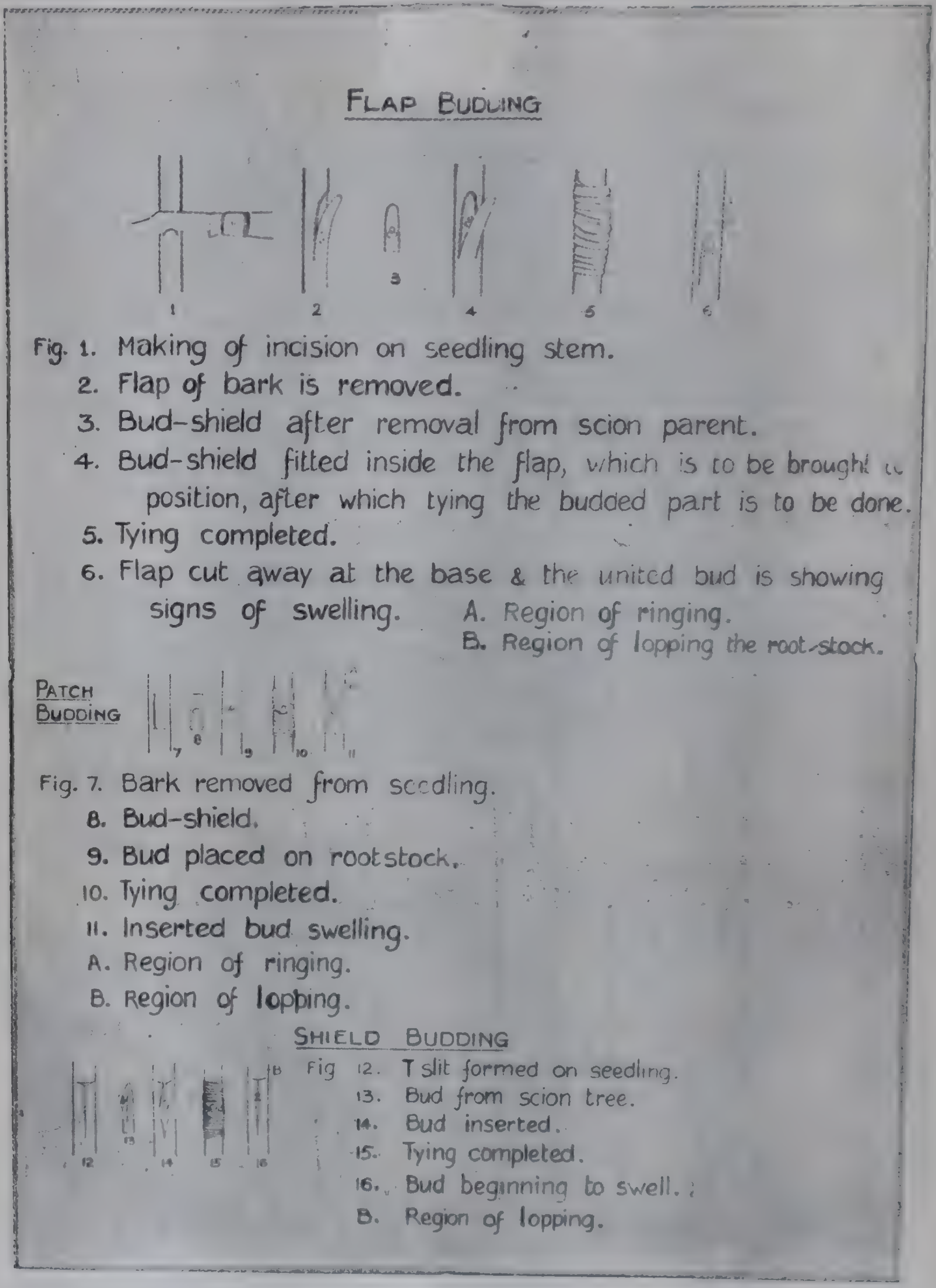


Fig. 1. Making of incision on seedling stem.
2. Flap of bark is removed.
3. Bud-shield after removal from scion parent.
4. Bud-shield fitted inside the flap, which is to be brought position, after which tying the budded part is to be done.
5. Tying completed.
6. Flap cut away at the base & the united bud is showing signs of swelling.
A. Region of ringing.
B. Region of lopping the root-stock.

Fig. 7. Bark removed from seedling.
8. Bud-shield.
9. Bud placed on rootstock.
10. Tying completed.
11. Inserted bud swelling.
A. Region of ringing.
B. Region of lopping.

Fig 12. T slit formed on seedling.
13. Bud from scion tree.
14. Bud inserted.
15. Tying completed.
16. Bud beginning to swell.
B. Region of lopping.

Fig. 41. Mango budding.

inserted bud. After the bud-sprout produces about two to three inches of new growth, the rootstock is lopped off immediately above the inserted bud.

Patch Budding :—A patch of bark is removed from the seedling stem, and a bud-shield of similar size is got from the selected scion shoot. It is then placed in the exposed surface on the seedling stem, and the operated parts are bandaged leaving only the bud exposed. The subsequent treatment is the same as explained above under flap budding, except that in this case there would be no flap to cover the bud or to cut away. (See Fig. 40 and 41.)

Shield Budding :—This is the same method as employed for budding oranges. A "T" or inverted "T"-shaped incision is made in the rootstock stem. The bud is removed from the selected scion parent with a small piece of wood attached to the bud-shield. The rind is raised and the bud is then inserted. Wrapping and subsequent treatment of the budded plant are on lines similar to that explained for patch budding. (See Fig. 41.)

Side Grafting :—The terminal shoots of the past season's growth, which have not yet become fully mature and assumed the greyish bark colour are selected for side grafting in a season when they are not in active growth. All the leaves on the selected shoots up to a length of about four inches from the apical

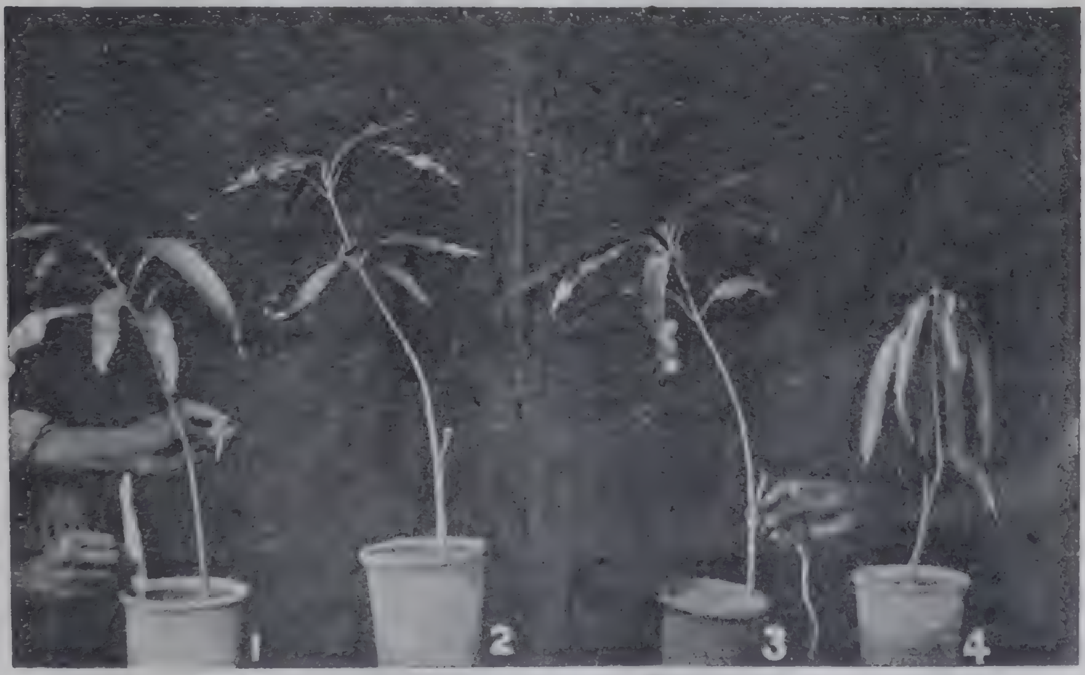


Fig. 42. Side grafting demonstration with potted plants.

bud are removed while still on the tree, leaving about half an inch of the leaf stalk. About a week later these defoliated parts of the shoots are cut away from the scion parent and side grafted on seedling shoots in active growth and of similar thickness. Two slanting cuts have to be made at the basal end of the scion shoot before side grafting, one cut being slightly longer than the other. An incision is made on the side of the seedling to a depth sufficient to allow the insertion of the scion shoot wedge. The longer side of the wedge should be fitted in contact with the seedling stem. The rootstock and the scion are then wrapped over firmly with raffia fibre. Within about a month the successful scion shoots will commence to grow ; and after these have produced two to three inches of new growth the rootstock stem above the grafting region may be cut off. (See Fig. 39 and 42.)

It has been found that the success by this method is greatest if scion shoots of 0.5 cm. diameter or over are utilised, and the grafting is done in beds in a season when there are no heavy rains, strong winds or intense sunlight. Some varieties respond to side grafting and budding methods of propagation markedly better than others. At Kodur, Neelum and Erra Mulgoa varieties have given much higher success by budding than Bangalora and Alphonso varieties ; and Neelum and Himayuddin than Alphonso and Peter. In regard to side grafting, Neelum, Khader, Himayuddin, Peter and Bangalora at Kodur and Khader, Janardan Pasand, Jehangir, Suya and Neelum at Kadiam (East Godavari district) have produced high success. Although high success is usually obtained from July to December, the weather conditions prevailing just at the time of and before and after the side grafting and budding operation, are of vital importance in determining the success of the operation as has been stated already. Heavy rains and excessively hot and dry atmospheric conditions form adverse factors, while cloudy and humid atmosphere and windless days are favourable.

It has been found possible to raise plants by side grafting method as also by budding with scion wood obtained from long distances and inserted three to five days after separation from the scion parent. In all such cases the cut end of the scion wood immediately after separation must be coated with paraffin and covered with wet moss and again wrapped with wet gunny cloth. If this wrapped scion wood is then kept in a metal or wooden case, the material can easily be despatched as a post or railway parcel.

Three to nine months after the operation, depending upon the season and care bestowed on them, the budded and side grafted plants will become ready for planting out.

Lifting of budded or side grafted trees from beds may result in a high mortality, if not done with great care. The success largely depends on the ability to induce a good lateral or fibrous root development on the surface soil and on the careful lifting out of the trees with a ball of earth in a cool period. The former can be achieved by application of a heavy dose of the well-rotted cattle manure or other organic manures like groundnut cake, compost or leaf mould both prior to the planting of seedlings in the beds as well as once after they have fully established themselves there and before the buds or scions are inserted. Timely applications of water to beds in dry periods is also necessary to prevent the roots going into deeper layers in search of moisture. In poor and very open soils the roots are never shallow and consequently, a considerable root cutting is involved at the time of lifting out the trees endangering thereby their lives. The ball of earth may also crumble in very loose soil. A good loam plentifully supplied with organic manure and regularly watered is a necessary requisite for successful raising of budded and side grafted mango trees in beds.

Root grafting :—Since no commercially successful method of vegetative propagation of mango rootstocks has yet been devised, some means of obtaining uniform material with a miscellaneous seedling basis of mono-embryonic mangoes are found necessary to enable the conduct of accurate field trials with mangoes. It has been pointed out by other workers that a stem piece of the rootstock often masks and outweighs the influence of the absorbing root system and, therefore, if only the root piece of the mono-embryonic seedling is grafted or budded to the scion, the stem influence of the rootstock will be eliminated, and a uniform material for field experiments will be available. The method of grafting or budding on the root piece of a rootstock will depend on the ability of the seedlings to withstand exposure of root till the union is effected, the ease with which the root piece can be grafted or budded to the scion, and perhaps also on the season of operation and age of the plant material used. After a series of trials at Kodur a successful method of root grafting has been devised. This consisted of lifting about one-year-old seedlings carefully in a favourable period such as a cool day in the rainy season as in September-October, with naked roots, and potting them immediately close to the edge of the pot. On the pot edge was made a U or V-shaped notch or cut, about one inch wide at the top and two inches

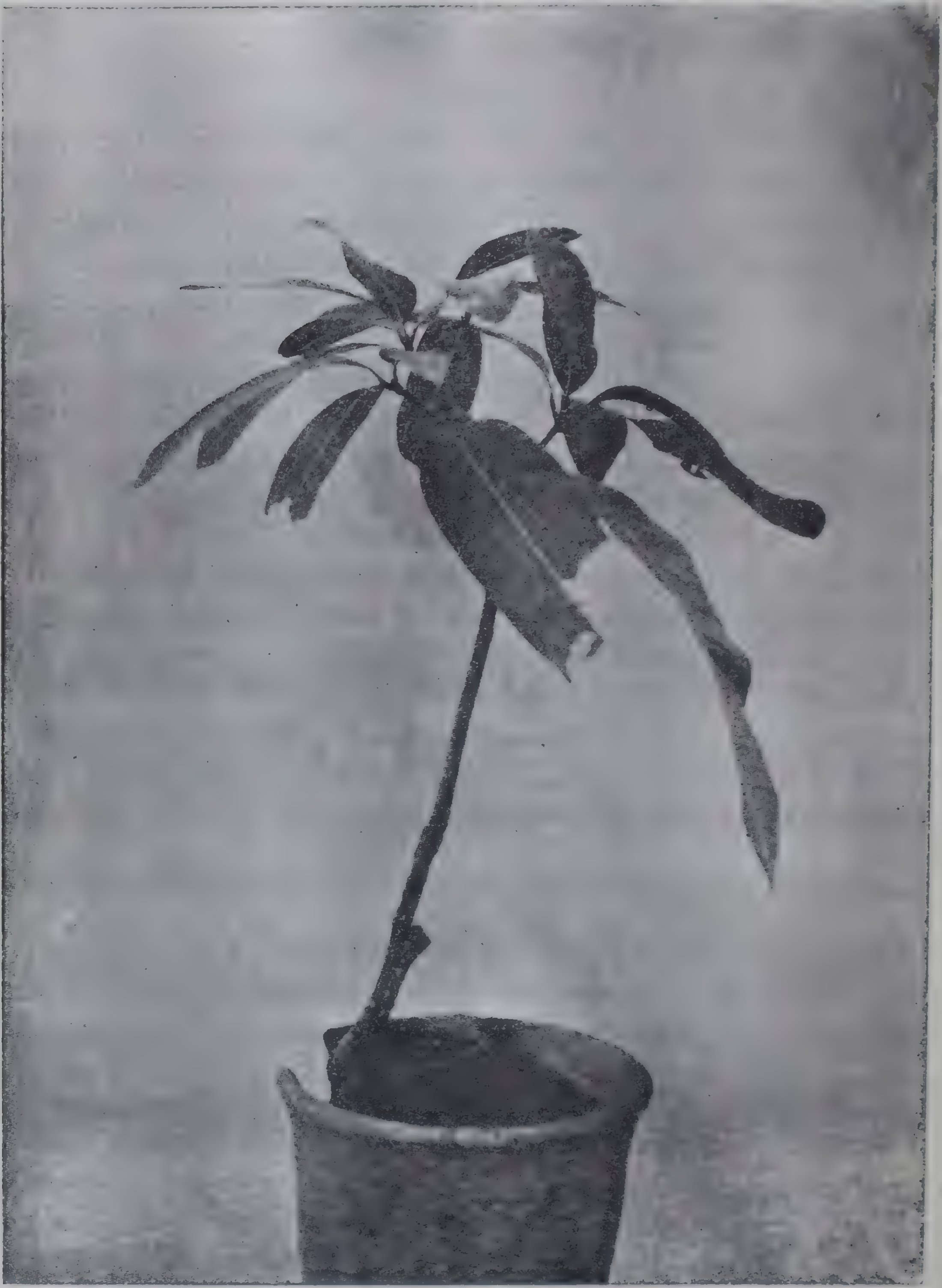


Fig. 43. Root graft of mango

deep. At the time of potting the seedling, a root piece of about three inches in length close to the collar of the plant was made to project out through the above notch. After a month's time, during which the potted plants were placed in shade leaning against a support and got established, inarching was done to the selected scion shoot using only the exposed root piece of the seedling. The success obtained in inarching or this root-shoot grafting has been as high as 100 per cent. in a very favourable period in 1937 with small batches. In a larger batch of seedlings lifted in 1938, the mortality of seedlings was only five per cent, due to lifting with naked roots in November ; and root grafting with these also gave a percentage success exceeding 95. The final percentage of root grafts obtained from originally selected seedlings in beds in large scale operations has worked out to an average of about 23. From the performance of root grafts of Neelum and Bangalora at Kodur, evidence has been secured to establish the truth of the hypothesis that, the variability in mango orchards raised on mono-embryonic seedling stocks can be greatly restricted by resorting to root grafting. The extreme variability in private orchards on mono-embryonic rootstocks is a feature that lends force to the plan of root grafting, at the same time emphasising the benefits of selection of superior scion trees for securing good and uniform orchard performance. Use of polyembryonic rootstock material and of root grafted trees may therefore offer a means of exploiting the advantages of scion tree selection, and therefore, is of practical value to mango producers.

Double-working :—Double-working is a necessary operation in top-working of grafted or budded trees of inferior quality. Double-working is also a natural complement to the use of root grafts, since double-worked root grafts are sometimes believed to enjoy greater uniformity in orchard performance than even the grafts on vegetatively propagated rootstocks. It is to be expected that, when a superior variety is top-worked over grafted trees of several inferior varieties, each with its own varietal peculiarities, different degrees of response may result. A knowledge of the relationship between the various combinations of varieties used as a rootstock, intermediate stem piece and ultimate scion, is essential to prevent the possible loss or disappointment in any indiscriminate top-working campaign. In order to gather such knowledge, trials on double-working have been under way at Kodur for a number of years. These have shown that double-working is as easy in practice as inarching, giving almost as high success with different combinations in the nursery stage. The percentage of double-grafts obtained from the original selected seedlings has ranged from about 51 to 72 in 1938. In these the second grafting was also inarching as the first grafting, and was done a month or more after the single-worked grafts were separated out from the scion varieties. Trials with four scion varieties on two different intermediate stem pieces on mono-embryonic, miscellaneous seedling stocks, have proved that double-working leads to a slight dwarfing of the final trees and a slight precocity. It has also been indicated that double-working with different combinations results in dissimilar growth and yield performances. Through appropriate selection of stionic combinations, it seems therefore possible to circumvent stock-scion incompatibility. It is however proved that it is futile to expect increased yields in normally shy-bearing varieties like Jehangir by resorting to double-working, because of the fact that such inherent defects as the existence of a low proportion of perfect flowers, cannot be altered or influenced by employment of this method of

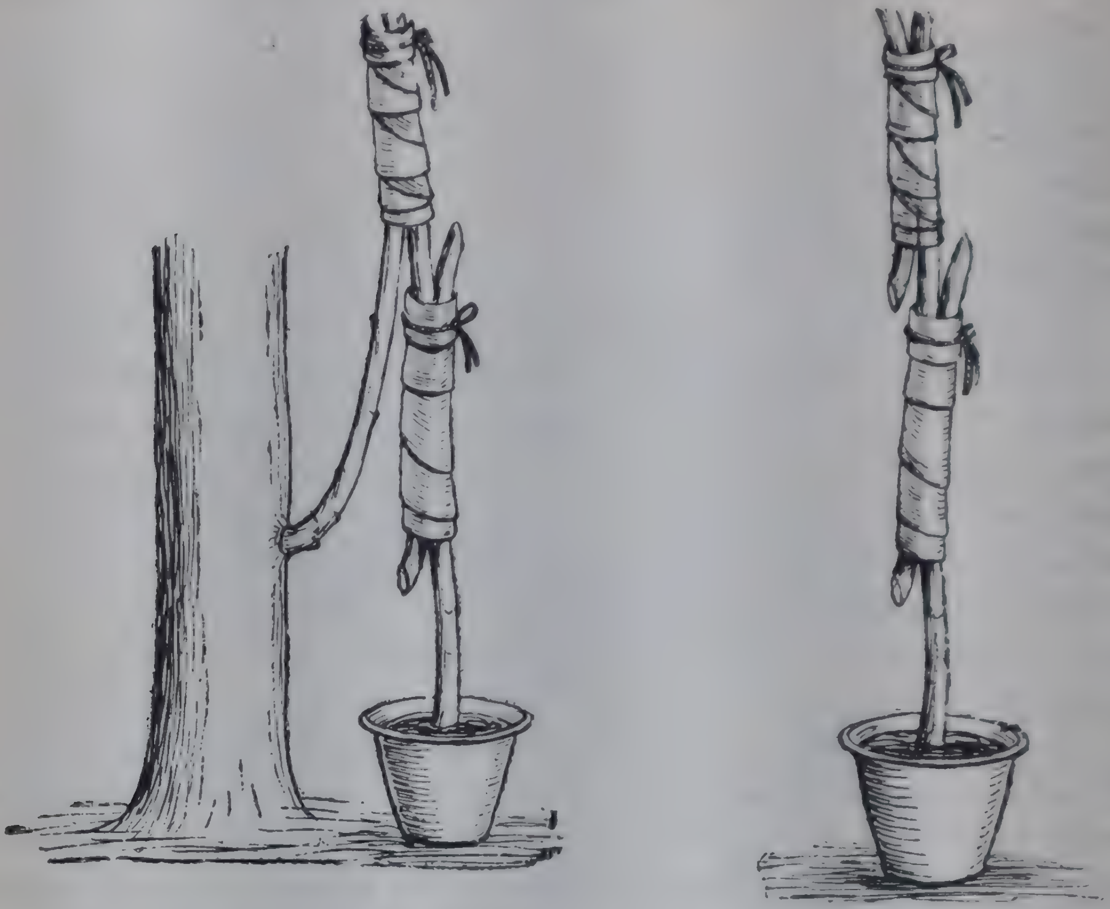


Fig. 44. Double-working.

propagation or by using the intermediate stem of a prolific variety like Neelum. Inherent bearing capacity of the variety is found at Kodur to be a dominant factor, not subject to material influences by any propagation method.

Cleft grafting :—This method as tried at Kodur gave a successful " take " of only 0.85 per cent. with Neelum or Bangalora scion variety, and is therefore considered to offer no commercial possibilities.

TOP-WORKING

The usual method of top-working mango trees of inferior varieties and of seedling trees into trees that would produce crops of superior quality consists of heading-back the former trees or some of their main limbs and selecting a few healthy and vigorous one-year-old shoots all around the trees out of the branches retained, and then grafting such shoots over to similar shoots of the desired superior variety. In actual practice, the grafts of the superior scion variety are carried in pots near the tree to be top-worked, and the scion shoots of the grafts are inarched to the selected shoots of the tree which was cut back. After the union between the shoots is effected, the potted grafts are separated out. The next step is to cut off all the ungrafted shoots of the inferior top-worked tree so as to give scope for the grafted shoots to grow vigorously. The bandages around the grafted shoots are also removed within a month or two of the operation. Because of the established root systems, the new scion shoots are able to make very rapid growth and produce fruits of the quality of the scion variety within about three years after top-working.

The foregoing brief description would show that the process of top-working by inarching is tedious, and would involve daily attention from the date of inarching to the date of separation of grafts for watering the potted grafts placed at different elevated positions on the top-worked tree. Some expenditure has also to be incurred on the erection of a scaffold for placing in position the potted grafts close to the selected shoots. On these grounds, top-working of mango trees by the above method has not made much appeal to the growers.

During the past two decades, a more convenient and a cheaper method of top-working mango trees is being practised by a few growers in the West Coast. This method is popularly known as "insertion," but it is nothing more than a form of side grafting. The method is briefly described below.

The operation of side grafting merely consists in the insertion of shoots from superior varieties between the bark and wood of the seedling or inferior tree. The operation is more successful on a tree with smooth trunk than on trees which have their trunks split or gnarled all over. In the latter case, the bark does not peel off easily, and possibly the union also cannot be effected expeditiously before the side grafted shoots show signs of withering. Cloudy days, humid atmosphere, freedom from heavy winds, rains and strong atmospheric heat for a few days during and after the operation are favourable factors for the success. The West Coast seems to provide the most congenial conditions for this operation, while under the hot and dry conditions of the Ceded Districts, the success is problematical.

After selecting the tree for top-working, a triangular patch of bark (one-fourth to an inch on each side of the triangle) is removed from the trunk with the help of a sharp knife and this is laid aside in shade for use at a later stage. Immediately below the lower corners of the triangular patch, two slits, two to two and a half inches long are made vertically downwards in the bark up to the inner wood. With the help of the ivory blade of a budding knife or with that of the steel blade, the bark of the tree between these two slits is carefully raised commencing from the upper side, from where the triangular patch was removed previously. The tree is now ready to receive the scion shoot of the superior variety.

Well matured terminal shoots of the previous season's growth of the scion tree form the best material for side grafting. This should be round, and should have a stem thickness of at least equivalent to that of an ordinary lead pencil. At the time of top-working the scion shoots should be dormant, but preferably ready to put forth new growth. Shoots in active growth are not desirable. A week or ten days prior to the date of side grafting, all the leaves on the selected shoots up to a length of about ten inches from the terminal bud may be removed, leaving about half an inch of leaf stalk. Immediately before side grafting, these defoliated scion shoots are cut off to a length of six to eight inches. At the base of these shoots two slanting cuts, each roughly one and a half to two inches long are given with a sharp knife to form a wedge shape. The wedge shaped scion shoots are then carefully inserted inside the flap of bark, raised between the slits on the stem of the tree selected for top-working.

The wedged surfaces of the scion shoot must fit like a glove within the flap, leaving no cavity between the scion shoot and the bark on one hand, and the former and the inner wood of the top-worked tree on the other. The triangular piece of bark removed previously is now fitted back to its original position. The scion shoot and the stem of the top-worked tree extending to about two inches above and two inches below the grafted region is then bound over with some strong rope. A grafting wax, made usually of three parts of resin, two parts of bees-wax and one part of coconut oil (by weight) melted together in a pot and cooled, is now pasted over the bandaged parts. Sometimes, even a paste made of cow dung and clay is smeared instead, but the above stated mixture seems preferable.

More than one scion shoot may be inserted all around the tree trunk at different heights. If even one of these scion shoots succeed, the whole inferior tree top has to be sawed away. It is advisable to perform this operation gradually in two or three stages so as to cause as little shock to the tree as possible. The grafting bandages and the wax are removed within about three months of the operation.

The method described above is of general application to fairly old trees. With young trees of less than about six years of age, it is usually unnecessary to remove triangular patch of wood for side grafting. A horizontal slit in the bark up to the wood may first be made on such trees, and at the extremities of this slit two vertical slits may be made downwards. The lifting of the flap of bark within the slits and the subsequent processes of side grafting are not dissimilar from those described previously.

In the West Coast, it is common to cut away the entire tree top in the case of young top-worked trees shortly after the side grafted shoots show signs of new life and produce a flush of new growth. About a year after the date of side grafting, some growers also earth up the tree up to the region of side grafting, leaving only the scion shoots above. Earthing up, however, is only possible and practicable when the side grafting has been done close to the soil surface. June-December is the season usually preferred in the West Coast for the operation.

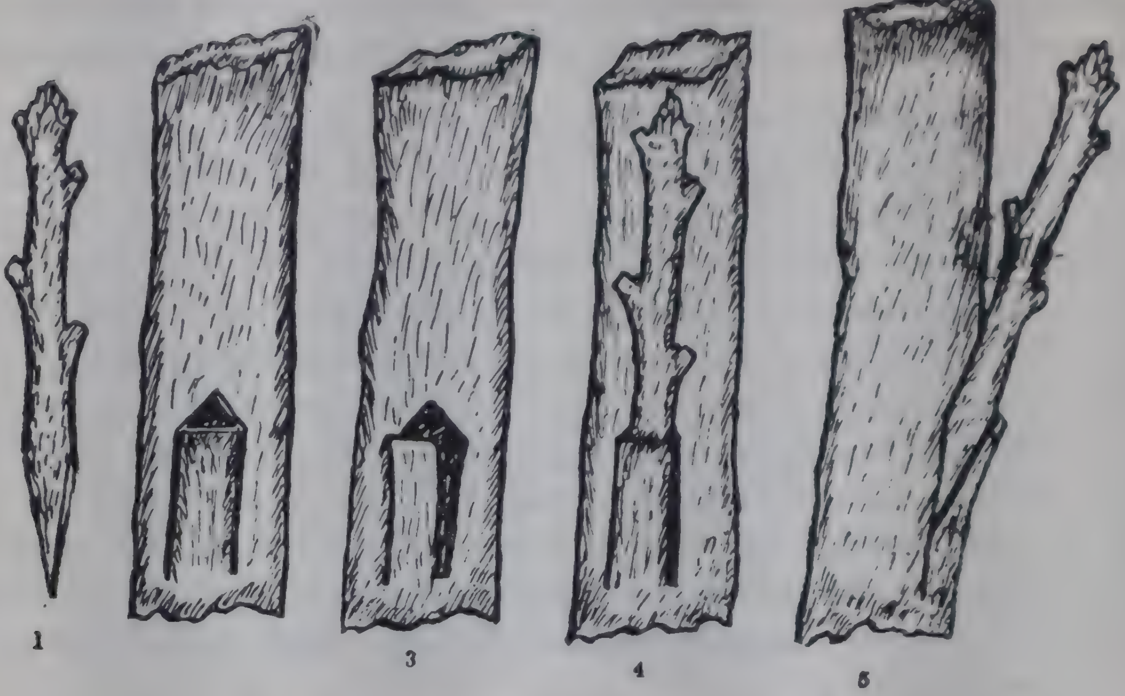


Fig. 45. Top-working by "insertion" method

Considering the potentialities of the method of top-working in effecting a marked improvement of our mango industry by converting the uneconomic seedling trees or grafted trees of inferior types into trees of better quality, it is hoped that the growers will give special attention to this line of improvement. Top-working by side grafting is a simple operation which does not demand much skill and training. The method offers a chance of increasing the utility and economic value of most trees that abound in large numbers even in the forest and uncultivated areas. Stray trees do not attract at present any attention because of their inferior fruit qualities. Similarly, several hundreds of seedling trees now grown as avenue trees along many of our roads in rural parts do not fetch much income to the local bodies. If all these are converted into superior varieties, the resulting benefit will be considerable. As stated elsewhere, the method of top-working as described above, seems however to be of value only under West Coast conditions. The success in other parts of the province is likely to be limited.

PURCHASE OF PLANTS

The general inefficiency of mango orchards in South India has been clearly brought out from the studies conducted at Kodur and observations recorded in several places. The amazingly large preponderance of inherently poor yielding trees is patent from the fact that during a four-year period (1936-1939) in a private orchard containing 1,632 bearing trees, only one single tree produced heavy crop of flowers consistently in the four years, while the percentages of consistently poor flowering or poor fruit yielding trees in the period were as high as 83.0 in Andrews, 84.2 in Mulgoa, 39.5 in Bangalora and 35.5 in Neelum. Taking the yield of any one of the four years into consideration, the percentage of heavy fruiting trees did not exceed 2.6 in the above plantation. These figures combined with the general observations elsewhere indicate that one of the most important lines of improvement that requires to be effected in the mango industry is to increase the proportion of consistently productive individuals. In other words, the prevailing orchards stocked with most defective plant material shall have to give place to more efficient performers, if regularity of bearing and enhanced crop yields are to be promoted or ensured.

That the above is a distinct possibility is brought out from the investigations at Kodur. The vegetative progeny of a selected parent of Neelum and those of another selected tree of Bangalora have all turned out to be efficient orchard entities, with a variability between individuals that is deemed extremely low, such that is not met with in private and indiscriminately raised orchards. Not a single tree in either of these two varieties failed to yield crop during the first three years of bearing. These denote that selection of mother trees is essential to foster good and uniform crop yields in Neelum and Bangalora, and possibly in other varieties of mango as well. This should convince the growers and nurserymen that the policy of taking scion wood from uniformly high yielding trees is a fundamentally sound procedure. Many of our nurserymen fail to adopt a rigorous selection of parent trees, with the result that the purchaser of the trees is necessarily finding mango farming to be a gamble, faced as he is with orchards predominantly stocked with poor cropping individuals. At the Fruit Research Station, Kodur individual tree records of over hundred varieties have been maintained, and on this basis the high cropping individuals in each variety over a period of years have been isolated. The vegetative progeny of such selected trees are made available to the public. Similar measures are required to be taken by every nursery, in the interests of the future prosperity of South Indian fruit industry. The South Indian mango producers are annually spending the receipts from a very few of their paying trees on the maintenance of a vast majority of useless trees growing alongside and around. The progressive deterioration in orchard efficiency can only be effectively stopped if the nurserymen select varieties and scion parents and scrupulously avoid multiplying trees of questionable or doubtful quality and performance.

It will be also well for the purchaser of grafts or budded plants to demand and obtain a written guarantee from the seller to the effect that the plants sold are true to name. Grafts should also have been separated from mother trees at least a month prior to the date of purchase. For long distance transport and for planting especially in out-of-seasons, large sized plants are to be deprecated. The scion and stock portion of the plant should be of uniform size ; and the graft union should be healthy and strong, showing no sign of weak attachment at any spot or any marked constrictions on the bark. The graft union should also be between 9 inches and 18 inches above the ground. Above all, the graft should be healthy, vigorous and having branches placed well around the main stem at some intervals, and not emerging in opposite directions.

Season of planting :—July to December provides the most suitable period for planting mango trees in most parts of South India. Where rainfall is heavy as in the West Coast, it is advisable to defer planting till the monsoon weather draws to a close, particularly in exposed and ill-drained sites. In other regions and sites, planting may be done in any part of the season excepting during hot and dry spells. A hot, dry and windy season is definitely unsuitable for the planting of all kinds of trees. It is also safer to plant out trees in the afternoons than in the mornings and in cloudy and humid days than when fierce sunshine and dry weather prevail.

Spacing :—The planting distance for mangoes will depend mainly on the nature and fertility of the soil and on the variety. In poor soils like those near Chittoor, the mango makes relatively moderate growth and consequently requires less spacing between trees. On very heavy and shallow soils the tree size may also be small, because of the difficulty experienced in the spreading of roots. In the very open sandy soils also, tree growth is not likely to be large unless ample care is bestowed on feeding the tree regularly with manures and fertilizers. On the other hand, in loamy or other open soils of good depth the foraging power of mango root is enormous, so that trees of magnificent size are secured. Even in open soils lacking in moisture in upper strata but supplied with ample at lower depths, trees grow to great proportions.

These render it difficult to lay down any hard and fast rule in the matter of tree spacing as applicable to any given region.

As a rule, seedling trees are known to be very much more robust in growth than grafted or budded trees. Among the vegetatively propagated trees also, a great disparity is found between varieties, and between the single and double-worked trees, the latter being much smaller in size than the former. Trees on polyembryonic rootstocks are also more vigorous in growth in early stages at least than those on mono-embryonic stocks ; and if this difference persists later in the orchard, it will entail the adoption of different spacings to these two types of stionic combinations. Among the varieties, Khudadad, Alphonso and Peter are very spreading in habit, while Kalepad, Gaddemar and Nazuk Pasand make relatively less spreading trees, with Baneshan, Rumani and Bangalora coming intermediate between the two groups.

Since the planting distance depends on the size that the fully grown trees will attain ultimately, a consideration of soil fertility, soil texture, depth, moisture holding capacity, varietal growth habit, propagation method and type of rootstock is necessary for a satisfactory decision. Ordinarily, however, 40 feet from tree to tree on the square system of planting is a safe distance to adopt, except on rich soils to be planted to vigorous growing varieties, in which case even 60 feet spacing may be found to be inadequate as in some parts of deltaic areas in the Circars, in padugai lands on the banks of Cauvery in Trichinopoly, as well as in the very fertile soils of several other districts. In extremely poor soils on hill sides as are met with on the lateritic or gravelly or rocky hills in parts of the West Coast and Chittoor, a 30 feet spacing is usually adequate.

PLANTING OPERATION

When planting any fruit tree which has been purchased with a pot or with a ball of earth attached to the root, great care has to be taken to prevent any damage to the ball of earth or to the soil mass around the root inside the pot. Injury to the soil mass or breakage of the ball of earth or pot means damage to the small root system of the plant. Such injury may occur in transit, during the planting operation or even in a short time after the actual planting is done. In the first case it is a good policy not to plant the trees in the open immediately on their arrival. The damaged plants may be first set out in a bed under complete or partial shade. After two or three months when the plants have recovered, they may again be lifted out carefully with a new ball of earth from the beds for planting out in their permanent places. In the second case, damage usually occurs as a result of careless handling of the trees or careless pressing down of the soil in the pit, due to which the roots may become damaged and the balls of earth broken off. In the third case, the damage mostly results from an uneven settling down of the soil in the pit after the planting operation. To avoid this, the pits or holes in the orchard may be dug a few days prior to the actual planting of the trees. The pits may then be refilled and watered copiously to wet the soil inside the pits. This will settle down the soil evenly inside the pits. At the time of planting only a small amount of soil in the centre of the previously covered pit need be taken out for accommodating the ball of earth around the root. The soil around the ball of earth should be firmly pressed down either by trampling with feet or by the help of a stout wooden stick or the handle of the tool used previously to scoop out the soil from the centre of the pit, without causing any injury to the ball of earth and the plant. Planting of trees carelessly in freshly dug-out pits and failing to press down the soil adequately, or pressing the soil so carelessly as to break the ball of earth, are frequent sources of casualties in the newly planted trees, and therefore should be guarded against.

There is no unanimity of opinion in regard to the size of the pit to be dug in the orchard for the planting. Large pits or holes are unnecessary except to determine the nature of lower layers and then to avoid locations underlain with rock or other adverse soil features. Normally, pits of the size of 2 ft. x 2 ft. x 2 ft. are deemed satisfactory, as has been stated already.

Application of any manure to the hole just before or at the time of planting is a practice that may result in serious injury to the trees. If the soil is poor in fertility and the owner is keen to provide a stimulus to tree growth from the beginning, it will be desirable to apply the manures to the hole 6 to 12 months before the planting date or after that date. In the former case the manure usually applied is 10 to 20 lbs. of well-rotted cattle manure, compost or leaf mould, which is evenly and thoroughly mixed with the soil and the pit watered profusely to wet the entire soil mass inside the pit. Only after the manure has decomposed well in a period of 6 to 12 months, the graft is planted out. Such a treatment is believed to be unnecessary in normal or fertile soils.

Since mango grafts are mostly sold in pots or some types of containers, it becomes necessary to remove the grafts out of those containers for planting, and also to remove all kinds of packing material. It is surprising that some growers do not even realise this point and have in the past planted the grafts with even earthen pots intact. Under such conditions the plants suffer greatly and eventually succumb. Retention of grass or straw packing around the ball of earth is also undesirable as these may attract white ant attack, even if the packing materials are sufficiently loose to permit root penetration to the soil through them. Every care is necessary to see that the roots are not damaged or exposed for long while de-potting or unwinding the packing material. The de-potting is usually done by turning the pot upside down, and striking the pot edge gently on a hard material, while one hand is firmly pressed to the soil with the plant stem held between two fingers. If the soil inside the pot is not very dry and loose, with a couple of gentle hits on the hard medium, the ball of earth separates out of the pot, falling on the hand placed beneath. The plant is then turned to its natural position, the crocks that may be sticking to the base of the earth ball are removed and the graft is then ready for setting out in the orchard.

After the graft is placed in the centre of the hole and the soil firmly pressed all around the ball of earth, a small basin of about three feet square is made with the plant in the centre. The bund around the basin should be at least six inches high to retain enough water inside the basins during irrigations. The level inside the basin may be the same as that of the rest of the field, except that it may gently slope from the tree trunk to the periphery of the basin so as to prevent water standing in contact with the trunk for long periods. The slope should not be greater than to give a depth of more than four inches at the edge of the basin, with the plant standing in the centre at ground level with only the roots buried inside the soil as in the pot previously. The basins are to be connected by irrigation channels, which when filled up will let in water to the basins first towards its edge and then gradually filling up the entire basin to a depth of about six inches at the outer extremity and about two inches at the most near the trunk. The first watering is to be done immediately after planting. The basin of the type mentioned above will permit a thorough soaking of the soil immediately around the newly planted tree to an extent as not to lead to prolonged water stagnation. A slight wetting of the surface soil is a practice that confers no benefits to the young tree and should be avoided.

Planting of the grafts or budded plants too low so as to submerge the bud or graft-joint in the soil is a widespread practice, which is to be discouraged as much as the planting of tree too high to expose a part of root system. It is best to plant the trees at the same depth in which it was in the pot or in the nursery bed, i.e., with the bud or graft-joints about 9 to 18 inches above the ground level. Such trees tend to be stronger than those planted too low or too high.

A large number of casualties also occur in young mango plantations due to careless removal of bandage from the graft-joint or by failure to provide proper stakes or supports to the young plants. The graft bandage should be removed within about four months after the graft is separated out from its mother tree. If retained longer, unseemly constrictions are produced on the plant and these may adversely affect the future growth. If grafts of more than four months old are purchased, the nurserymen will ordinarily remove these bandages prior to the sale of these plants. Otherwise, the purchaser has to attend to this operation. Injury to the plant at the time of removal of bandage or a bad shaking may result in the death of the plant. With the help of a sharp knife, a careful person can easily snap the bandage at different points without causing any scar on the plant. If the bandage is snapped all through vertically, there is no need to pull off the snapped bandage. When the plant grows, it will automatically throw out this snapped bandage. In windy localities, even after a proper removal of the bandage there may be the danger of separation of the graft at the graft-joint due to heavy shaking received by the plant by the force of wind. To avoid this damage, two wooden stakes may be planted opposite to each other and about a foot away from the trunk of the young plant on either side. Ropes may be tied to these stakes so as to make a firm but not too tight loop around the graft-joint. This support will prevent excessive swaying of the tree and the dislocation of the graft-joint during stormy weather. It is possible to think of other supports to achieve the same object.

For a proper and successful establishment of the young tree in any new site, it is necessary to see that the least damage or check to the growth is received at the time of planting. A plant which is just commencing to produce new shoots or in which the new shoots have been formed only a short while before planting, and therefore, are still in a growing condition, is not fit for planting. Only those plants in which growth has ceased for the time being and all shoots have become mature with a total absence of tender leaves or shoots on them, should be selected for planting. The rest may be kept either in pots or in nursery beds till they reach a dormant stage.

After the plant is established in its new site, and apart from regular irrigations and inspections for control of diseases and pests, the one operation to be regularly and specially attended to by the purchaser is the removal of the side shoots emerging from the part of the graft or budded plant which lies below the bud or graft-joint. All such new growths should be removed as soon as they are observed. Otherwise they will seriously affect the growth of the tree and may even kill the superior scion shoot above the joint.

IRRIGATION

In South India watering of mango plantations is very rarely done three or four years after planting. During this early period, the amount of water required per irrigation, the frequency of irrigations and the intervals between any two waterings, will depend upon a variety of considerations and, therefore, it is not possible to issue any definite recommendations for general procedure. If the trees are planted during the monsoon, watering may not be necessary at all in a tract like the West Coast unless there are long, dry spells. Again in dry season, the interval between irrigations will depend on the kind of soil ; for a retentive soil will naturally demand water at longer intervals than open soils. The depth of water table is also an important consideration. The only general advice that can be given in this matter of irrigation is what has been already touched upon elsewhere viz. :—(a) apply water only when the first nine inches of soil have gone dry ; (b) apply as much water as would soak a greater part of the root area ; (c) do not apply water very close to tree trunk ; at any rate, prevent the water coming into close contact with the bark or graft union and standing there for long periods. As to how the trees should be irrigated is a question that can be answered only after knowing the topography of the soil and kind of intercrops grown in the plantations. Where only hand watering is done, it is comparatively an easy matter, as only small basins need be prepared. Such basins, however, should cover the entire root area, which for practical purposes, can be taken to be of a diameter one to three feet greater than that of the spread of the tree. A slightly raised patch near and around the tree trunk should also be provided. Even when irrigation is applied by other means, basins will answer the purpose in most of the plantations during the initial period of three or four years, provided the basins are widened from time to time to cope with the root spread. Where intercrops are grown, the water applications to mangoes will naturally be governed by those given to intercrops. If the latter are to be given flood irrigation, care should be taken to see that water does not stand in contact with the trunk of the trees for long periods ; and at the same time channels are provided along the tree rows for drainage of surplus water. Even if intercrops are irrigated by other methods, these two precautions have to be borne in mind.

Manuring :—In regard to this matter also sufficient amount of reliable data is not available to advance definite recommendations. In most mango groves of South India, as in many places elsewhere, manuring of bearing trees is an almost unknown practice. During the first three or four years of the orchard life, however, two to five baskets of well rotten cattle manure or two pounds of groundnut cake, with or without two pounds of bonemeal may be spread around each tree about a foot or two away from the trunk, and incorporated into the soil. Watering of the tree should follow this application. In Western India, an application of 20 lbs. of cattle manure per tree when a year old, increased by 10 lbs. per tree annually up till the dose reaches 100 lbs. per tree, has been advocated. To these, bonemeal is also added at the rate of 5 lbs. per tree when a year old and increased by 1 lb. per annum up to 15 lbs. per tree. Wood ash at the rate of 10 lbs. per tree may also be applied besides, and this may be increased by 2 lbs. per tree per annum up to 30 lbs. per tree. Heavy applications of organic manure like cattle manure or cake to bearing mango trees is believed by some to be unfavourable for fruit production, though helpful for vegetative growth.

Grove culture and intercrops :—Mango is not exacting in its cultural requirements. This does not mean that the groves should be left to themselves for rank growth of weeds, which will ultimately starve the trees of moisture and nutrients. During the early non-bearing stage of the trees, it will be profitable to intercrop the mango plantation with any kind of vegetables or leguminous crops like sunnhemp, *pilli-pesara, dhaincha*, horsegram etc. In fact any other crop may be grown except those like paddy, which will demand heavy irrigations, or tall-growing crops which may adversely shade the young trees for prolonged periods. Even small fruits like papayas and pineapples can be grown if kept far away from the trees. Intensive intercropping will also be beneficial in keeping down the weed growth. When the trees attain the bearing stage, one or two ploughings or hand diggings to the soil every year will be necessary to conserve moisture and keep off weeds. Occasionally, green manuring of the plantation may also be done with a leguminous crop to replenish the organic matter content of the soil. In such a case the ploughing-in of the green manure may be done during the monsoon.

In parts of South India where heavy north-east monsoons keep the mango orchard soil wet for long periods, just preceding the annual blooming season, it is believed that deep ploughing of the soil in October-November or early December is of some value in arresting growth in bearing trees and encouraging the formation of flower buds. Some growers resort to even more severe treatments such as removal of soil around the trunks to expose the surface roots to a depth of about 12 inches for a period of two to three weeks in early December with the hope of forcing out a blossom crop. Observations from a small scale trial at Kodur on this treatment have failed to indicate any beneficial effects of the treatment, since the root-exposed trees flowered as well as the untreated trees of the same variety and age in the year (1944) in which the trial was performed. It is possible that in a different environment or soil and in a different season the results may be different. At any rate, root exposure is not a treatment that can be recommended till after its influences are determined from accurate and comprehensive trials.

Pruning :—Pruning in mango is only restricted to removal of dead and diseased wood and of live parasites like *loranthus*. which are specially bad in humid regions. Since the mango produces fruits at the ends of shoots, tipping back of terminal growth may restrict the bearing area and thereby reduce crop size, incidentally favouring vegetative growth in profusion. In Florida it is reported that it is desirable to prune off certain branches from the centre of the trees so as to keep the crown open to admit light and air. Such a procedure seems to be of dubious value under South Indian conditions, where heavy yields are commonly found associated with unpruned trees possessing dense foliage, even though much of the crop is restricted to the exterior regions of the top. Thinning of the top in the case of trees of such majestic height and proportion as the mango may also be found to be an uneconomic proposition under our conditions. There are, however, several varieties of cultivated mangoes which tend to branch low and spread out irregularly to form scraggy trees. Some of these send out large branches so low as to interfere with grove cultural operations. Training of the trees from the early stages, by eliminating low side shoots or pruning the lower shoots to an inner bud will be helpful in encouraging a more erect habit. Where production of grafts is done extensively, it is also possible to utilise to some extent the low hanging growths as scion material. This, combined with the cutting off of misplaced branches will clear up the lower regions of the tree to facilitate culture.

Girdling :—A method of striking the trunks and main limbs of bearing mango trees with an axe to remove a small part of the bark up to the inner wood is commonly done in several parts of South India at an interval of two to three years. This chopping is practised from October to December with the hope of inducing shy-bearing trees to bear crops, although some persons practice it as a routine operation at the above stated intervals on all trees of good or indifferent bearing capacities. The choice of a long interval between the treatment is said to be governed by the fact that the wounds heal slowly, and therefore an annual chopping may fail to influence the bearing, while on the other hand, it may endanger tree life. The practice is a crude imitation of girdling or ringing, which is a recognised practice in the culture of some grape varieties and also of some other deciduous temperate zone fruits. Trials with girdling of large limbs and trunks, by stripping off the bark to a width of one-fourth to one-half inch either completely or in the form of two semi-circular rings, about four inches apart and in opposite directions, have not indicated any appreciable increase in crop yields or in promoting blossom emergence in shy-bearing trees or parts thereof, when performed about a month before the normal flowering period. These practices as well as root pruning cannot at present be advocated, therefore, until more light is thrown on them by further investigations.

Smudging, or production of heat and smoke under mango trees for a period to induce blooming is also another practice on which no information is yet available under South Indian conditions, the few trials conducted at Kodur having produced inconclusive results.

CROPPING

Some grafts and budded trees begin to bear a few fruits in the second year of planting, but a vast majority bear the first crop only in about the fifth year of planting. In the case of weak or unhealthy trees, it is advisable to pick off the blossom during about the first four years of orchard life. A normally full crop is expected in about 12 years, although even after this period up to about 20 years the yields may show a tendency to rise progressively. The polyembryonic seedlings behave like the grafts in the above respects, but the monoembryonic seedlings crop later in

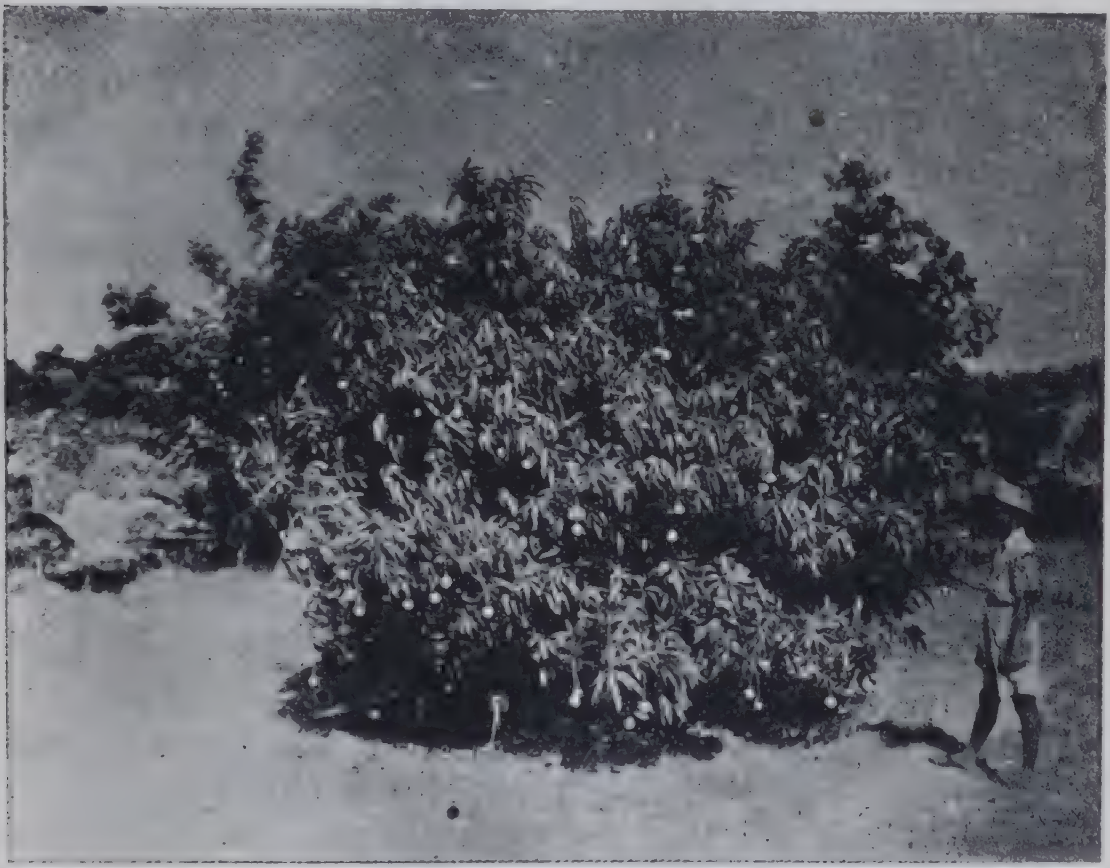


Fig. 46. A young mango tree in crop

life than the above, commencing to bear from about the sixth year and reaching a normally full harvest only after about 15 years.

The main harvest season opens with the West Coast mangoes in February or March, depending on the season, and is at its height there in April-May. In the rest of South India the main harvests last from April to July in the Circars, and May to August in Rayalaseema, Central districts, Tamilnad and Mysore States, in normal years. Flowering usually starts in early December in the West Coast and in December-January in the rest of South India, with the dates advancing in years of low rains in the north-east monsoon and receding in the years when the blooming season is preceded by or is synchronised with wet weather. In off-season cropping years, there may be two or more waves of blossoms, one of the most usual being in September, fruits of which mature in December-January. The influence of weather on the date of blooming is a marked feature in South Indian mango production. In Rayalaseema, the mangoes may begin to blossom even as early as November, while in other years flowers may not emerge till the middle of January. In 1945 for instance, six varieties were in full bloom at Kodur by the close of November, while in 1946 no flowers appeared on any variety till the close of the year, the first flowering having been noted only on 20-1-'47. The influence of weather on off-season crop production is believed to be equally great.

The fairly frequent occurrence of lean years in mango production and the shy-bearing tendencies of many varieties are well-known to form the limiting factors which have caused concern to the producers all over the mango growing regions of the world. Many have suggested that mangoes are subject to alternate bearing or to the phenomenon of periodicity of bearing, while others have pointed out that good or bad cropping years in mangoes occur at indeterminate intervals and do not conform to any alleged conception of rhythmic or cyclic crop production. The causes of scanty fruiting in many varieties have been also suggested to be due partly to the genetic make-up of the individual and partly to the varietal characteristics. From a series of investigations at Kodur into the blossom biological, pollination and growth aspects of the mango, it is now possible to have some idea of the causes that contribute to the perplexing crop uncertainties which upset the producers' expectations frequently and to the swing from heavy to light crops.

The investigations into the relation between growth features and crop production have shown that under Kodur conditions, the annual growth in such commercial varieties as Neelum, Bangalora and Baneshan is characterised by two distinct active phases, one occurring normally from February to June and another in October-November. Minor growth flushes occur in other parts of the year as well, mainly in December. The relative amount of extension growth, the peak of growing season, the duration of the growing period, and consequently the time of growth cessation vary to some extent between varieties and in the same variety from season to season. A cyclic growth tendency from year to year is not noticeable. Previous performance and the nature of origin of shoots have a determining influence on the production of laterals. For instance, shoots that carry fruits to maturity in one year produce a much lower extension growth and new laterals on a smaller number of shoots in the same year than those which failed to flower in the year or in which the flowers had shed early in that year. Production of flowers and fruits, which is the ultimate manifestation of tree performance from the grower's point of view, is found to have a direct, close and easily definable relationship with the growth features in the preceding season. Since growth in its turn is influenced by a variety of factors, such as seasonal conditions, tree metabolism and cultural practices, it is necessary for the grower to understand the correlations between all these factors for comprehending the contributory causes of productivity.

From the studies conducted at Kodur into the relationship between growth features and blossom bud formation, it has become clear that the prevalent belief to the effect that shoots that flower in one year are incapable of producing a crop in the succeeding year, is erroneous. It is also found that mango flowers are borne largely on the shoots that emerge in the first flush of the previous year. Although a higher percentage of leaders than laterals of that flush produce flowers, the latter shoots because of their greater abundance on the tree, exert a profound influence in increasing the gross flower crop. None of the shoots that carry fruits to maturity in a year, seems to be able to bear a crop in the succeeding year, which means that this class of shoots is less efficient than those in which the flowers shed early or in which flowers were not produced in that year. An early production of shoots during the first flush, an early cessation of growth during the same flush, and complete cessation of any visible signs of growth in the season immediately preceding the flowering period, i.e., in about December seem to be conducive to blossom production and to promote annual bearing in mangoes. Heavy flowering is followed by retarded growth activity in the following growing season, but this need not necessarily mean that optimum growth features cease to exist to enable the emergence of a crop of blossoms in the following year. It has already been mentioned that shoots which shed their flowers early in the season are capable of bearing flowers in the succeeding year. Further, although the production of flowers and of shoots that flower in the succeeding season in normal cropping trees go hand in hand every year, thus ensuring regularity of bearing, even in heavy cropping trees fairly large percentage of laterals produced as late as October to December in that year are in a position to produce blossoms in the season immediately following. This is specially so in some varieties like Neelum and Suvarnarekha. In the main flush, the largest percentages of growths that flower in the succeeding season are those that emerge in about April, while those that succeed have progressively impaired blooming tendencies in the succeeding season. Considering the length of shoots, it is found that those of medium length have the most efficient blossoming performance in the following year.

The findings from the blossom biological studies go to establish a high positive relationship between the percentage of perfect flowers and the number of fruits carried to maturity. An examination of over 93,000 flowers of 16 different varieties in 1939 at Kodur showed that the percentage of perfect flowers varies from 16.47 in Neelum to 3.41 in Alampur Baneshan, while in 1940 the percentage in Jehangir was only 1.25, with not a single perfect flower in one panicle. Since only the perfect flowers in the mango can set fruit and female flowers do not occur, a high percentage of perfect flowers is bound to be closely associated with high productivity. This is confirmed from the observation made over a number of years to the effect that Jehangir trees often producing heavy blossom crops fail to set a good fruit crop. The yields are also believed to be influenced by the facilities available for pollination and fertilization of flowers. It has been revealed in the course of hybridization work at Kodur that certain combinations of varieties as female and male parents or *vice versa* are more appropriate than others for optimum fruit set. The nearness of a suitable pollinising variety may prove as conducive to fruit set as the unavailability of suitable pollen would be for crop failure. Variation in flowering season may also bring about the latter result.

In the light of the above stated information, the causes of erratic crop production in mangoes may become intelligible. Heavy rains occurring in December may stimulate vegetative growth at the expense of flower production, thus altering a prospective on-year to an off-year. Adverse seasonal conditions may also restrict growth in the first flush or prolong growth, thus limiting the potential bearing capacity in the succeeding season. Strong gales, prolonged dry spells, frosts or heavy rains, or pest or disease incidence during the pollination period may also be injurious to fruit set, thus proving that blossom is only a preliminary to fruit and not a guarantee to harvest size. It is possible that several varieties like Neelum which are capable of flowering more than once in a season or year may tide over the adverse seasonal influences to a degree. Nevertheless, the marked influence of seasonal conditions on crop size and to an extent of cultural practices on the same, cannot be minimised. The influences of certain environmental conditions are so great as to destroy the crops in widespread areas or a region in one year. But all such adverse influences do not naturally occur according to a set plan, nor the records of individual trees bear out the truth of the so-called biennial bearing phenomenon in so far as the mango is concerned. The preponderance of consistently poor cropping individuals and a few consistently heavy cropping trees in orchards provides a definite testimony against the existence of biennial or rhythmic bearing tendencies in mango. The consistently good crops in clonal progeny plots secured at Kodur over some years is an additional argument. The incidence of lean years at unregulated intervals must therefore be ascribed to causes other than the natural tendencies of the crop ; and some of these have been specified in the foregoing pages.

Such suggestions as have been made for deblossoming, ringing, pruning and fertilization to overcome the supposed biennial bearing, have to be presumed to be based on erroneous presumptions, at least at the present stage of our knowledge and under the

South Indian conditions. While the importance of cultural practices can never be minimised in profitable mango production, it is well to recognise certain limitations of such practices also. That selection of parents has a determining influence on crop production, has already been emphasized. The inherent defects such as the low proportion of perfect flowers is another limitation that cannot be altered by cultural means. Heavy bearing has also been found to be associated with the ratio of style length to stamen length. This too is a feature that is incapable of modification by artificial methods. Selection of varieties and parents, of off-season bearers or of those that are capable of producing one or more crops when the first is destroyed, are some of the means open to correct the widespread erratic production. Selection of trees and varieties which have cluster bearing habit or which can withstand strong wind, or are resistant to hopper attack, are other profitable lines of improvement.

The yield of mango varieties and trees is naturally influenced so greatly by age, seasonal influences, nature of the site and care bestowed that a reliable estimate seems impossible. From the crop records at Kodur it appears that, a yield of about 60 fruits per grafted or budded tree would be a fair average for the fifth year of planting in a normal year. The yields increase progressively up to a maximum of 3,500 fruits or about 600 lbs. in the tenth year, with an average of not above 325 lbs. in Bangalora and 175 lbs. in Neelum in the seventh year. The huge variations between varietal yields are brought out from the fact that in 1945-'46 the maximum tree yield in about eight-year old trees among those classed as the most efficient performers of the year, ranged from 720 fruits in Neelum to 3,355 fruits in Pacharsi. With trees in full bearing and of about 20 years of age, a yield of 800 fruits per year in normal years and on normal soils with varieties like Pairi, Neelum, Bangalora, Rumani, Suvarnarekha and Baneshan may be considered as good, with the maximum reaching above 3,000 fruits ; whereas in shy-bearing varieties like Jehangir the maximum yield with such trees may not exceed 250 fruits.

PICKING AND PACKING

As a general rule, it is advisable to pick for local trade fruits which are almost or fully ripe on the trees, while for distant transport the fruits may be picked even about a week earlier and before they soften. Certain varieties like Neelum and Bangalora stand long distance transport better than others, and therefore are popular in commercial plantings. Some varieties also remain green when ripe, while others like Chinnasuvarnarekha and Janardhanapasand have brilliant colour even a little while previous to the attainment of full maturity. Softness to the feel is therefore the only reliable index that can be adopted for fruit picking in mangoes, although in some varieties, however, colour shades of different intensity are observed at the time of approach to full maturity, the shades generally deepening with the approach of ripening stage. Careful observations on each variety should afford the necessary indication to the growers of the optimum stage for harvest. This is an important matter, as immature fruits when harvested can never develop the full flavour and taste of fully mature fruits.

The fruits should be handled very carefully at all stages including at the time of picking. Any bruising of the fruit may cause serious blemishes or even complete rotting. The fruits may be picked singly by hand or with a metal ring to which is attached a net and which is fixed to the end of a long bamboo or wooden pole. A sharp edge on the inner side of the ring helps to break the fruit stalk, on which the fruit drops to the net. The fruit is then brought down and placed in baskets provided with thick straw or grass padding, and kept under tree shade. The American " Fruit harvester " with a clipper attached to the thin end of a bamboo and having a spring arrangement has not been tried here for picking mangoes. It is said that the above instrument does not pull the fruit stalk but cuts it with a jerk, and that the same can be prepared cheaply.

Ripening of mangoes is done for local markets or home consumption usually by spreading the fruits in single layer on paddy straw with two or more such layers placed over each other. Only such straws that are soft and that will not injure the fruit are used. The ripening is done inside a warm room or in closed boxes. The straw bedding and covering contribute the warmth, necessary for hastening the ripening process as well as probably to improve colour.

Ordinary bamboo baskets of various shapes and sizes are used in South India for sending fruits to local and distant markets. For overseas trade, special wooden crates are desirable. Such crates may be well ventilated and may hold fruits in single layers. Each fruit is wrapped in thin tissue paper and packed inside the crates with some soft material like grass, straw, or paper clippings. One of the crates suggested in Bombay is capable of holding about 100 fruits. It has holes for ventilation on the sides, each about one-half inch in diameter. The wood used is about one-half inch thick and the depth may vary to suit the variety. Coir ropes may be used to serve as handles on two sides. The boxes may be fastened by wire or nailed down carefully. Cheap and hardy fruits like those of Bangalora are not packed in baskets or crates, but are loaded as such in wagons for sending to Western and Northern Indian markets.

ECONOMICS

Accurate data on mango production cost are not available for the whole of South India for any of the cultivated varieties. However, the following figures relating to a plantation at the Fruit Research Station, Kodur may serve to give a rough idea of the requirements and profits, during the first few years of orchard life. These figures may hold good for well-kept private orchards also in respect of cost of production, except for one important item. Being an experimental area, it was not possible to raise intercrops in this plantation, while in a commercial grove intercropping is rarely left undone. This has served to lower the receipts appreciably. It is therefore to be expected that the profits from a bearing mango grove would be more than that indicated in table II.

Storage :—Trials with cold storage of mangoes have been in progress at Poona. In preliminary trials conducted there with Alphonso variety the fruits kept well for over a month at about 40^0 F. Hard green but mature fruits of Langra mango variety were found to keep well at 45^0 F. for four to five weeks in the Punjab. Sufficient trials on storage of commercial varieties in South India have not been carried out. Those that have been conducted at Poona and the Punjab on the cold storage of mangoes are not of much benefit to South India, as the harvested fruit undergoes considerable changes during its transit from the orchard to the cold store. It is wellknown that varieties differ markedly in their keeping quality both under refrigerated conditions as well as under ordinary orchard storage conditions. While a hardy variety like Bangalora can withstand even a week's journey in a railway wagon even without any packing, most of the choice South Indian table varieties can never stand such harsh treatment. The best keepers as well as the poorest among the South Indian commercial mangoes as known at present are the following :

TABLE II.—PRODUCTION COSTS AND INCOME FROM A MANGO GROVE AT KODUR

AREA—4.33 ACRES

Varieties : Neelum and Bangalora

Operations	Preparatory cultivation			First year			Second year			Third year			Fourth year			Fifth year			Sixth year			Seventh year		
	Rs.	A.	P.	Rs.	A.	P.	Rs.	A.	P.	Rs.	A.	P.	Rs.	A.	P.	Rs.	A.	P.	Rs.	A.	P.	Rs.	A.	P.
Cost of plants ...	...			40	8	0	...			...			...			...			...			...		
Manual labour ...	48	7	9	33	13	0	79	8	0	53	6	0	36	3	4	76	6	0	16	10	0	11	8	0
Bullock labour ...	17	15	3	5	7	6	24	9	0	47	4	0	19	2	0	48	12	0	21	6	0	36	14	0
Irrigation ...	6	4	0	...			14	12	0	13	7	0	...			3	2	2	...			...		
Manures ...	...			...			5	2	0	...			...			...			...			...		
Other Expenses ...	1	4	0	3	12	0	7	14	0	18	1	0	17	9	3	25	9	7	27	8	5	12	0	0
Total ...	73	15	0	83	8	6	131	13	0	132	2	0	72	14	7	153	13	9	65	8	5	60	6	0
Income ...	...			...			...			...			...			4	0	0	211	14	0	362	12	9

The profit of about 500 per cent realised in the seventh year from the above plantation is deemed to show that mango growing is a very desirable proposition.

Best Keepers :—Alphonso, Mundappa, Rumani, Neelum, Mulgoa, Baneshan and Bangalora.

Poor Keepers :—Peter, Suvarnarekha, Khudadad, Rajumanu, and Kothapallikobbari.

It is generally believed that such mangoes that get a wrinkled skin in storage usually keep the longest. Some of the seedling fruits are reported to keep well for months without rotting, although after such prolonged storage, the juice may get reduced to a hard pulp and the inside stone may consequently rattle. Combination of such good keeping quality with superior table fruit characters is a work which may be possible through hybridisation.

Products :—Mango canning is gradually making some headway in South India, but there is room for intensive research to determine the best variety for canning as well as for other products. At Kodur and at Kadium, Baneshan has given an indication of being suitable, while Neelum and Bangalora were not found to produce palatable canned slices in syrup. Canned pulp of several varieties as well as bottled squashes or juice are also seen to be of good quality, especially from the juicy varieties. Pickles, chutney, dried or dehydrated pulp in the form of "mango leather" are products of great promise. Candies, crystallised or glaced fruit pieces, and jams, or even marmalades, may be possible. The possibility of utilising the stone kernels has to be investigated. The use of mango for culinary purposes is also a subject that offers a great deal of scope for research.

PESTS AND DISEASES

The following information on some important mango pests and diseases and their control measures has been prepared with the help and guidance of the Government Entomologist and Government Mycologist, Coimbatore.

PESTS

1. BLOSSOM HOPPERS (*Idiocerus* sp.) :—Adults and nymphs of these wedge shaped brown insects infest the blossoms and injure them by sucking the sap. The flowers ultimately shed or fail to set fruit. The secretion of a sticky juice follows the hopper attack and provides a favourable ground for the development of sooty mould fungus, rendering the leaves and flowers dark in colour. The pest occurs throughout South India and accounts for the failure of almost the entire crop in some seasons. Spraying

the tree twice with fish oil rosin soap (strength 1 lb. in 10 gallons of water) at an interval of 10 days is effective in controlling this pest. The first spraying may be best done when the flower buds begin to swell. Dusting with sulphur has also been advocated by workers in other parts of India and is possibly better in effect.

2. STEM BORER (*Batocera rubus*):—The stout grubs of this large beetle bore into the live stems and branches and often kill them outright. This causes serious loss in certain years. Cracks in the bark and the presence of sawdust like powder near the tree are indications of the attack. The grub can be extracted with a bent rod or piece of wire, with a hook at one end. Where they are inaccessible for such treatments the holes may be plugged with cotton or rags soaked in equal quantities of creosote and chloroform and closed with wet clay or mud. If all cracks are fully closed thus, the grubs inside will be suffocated to death. A paste made of crude carbolic acid (1 pint), soft soap (2 lbs.) and hot water (1 gallon) may also be used to close the hole.

3. FRUIT FLY (*Chaetodacus ferrugienous*):—The eggs are laid inside the fruits and the white wriggling maggots burrow into the fruit pulp. They pupate in the soil. The fruit fly is a serious pest in some seasons and occurs in all parts of South India, but it seems to infest only some varieties, especially the late varieties. All attacked and fallen fruits, particularly the first affected fruits should be gathered every day and destroyed under fire. Spraying a deterrent like crude oil emulsion at a strength of 1 lb. in 10 gallons of water may be tried to prevent flies from laying eggs. Gammexane dusting has also been suggested by some. Since the maggots pupate in the soil, raking of the soil round about the trees will be helpful in destroying the pupae.

4. LEAF-EATING CATERPILLAR or SLUG CATERPILLAR (*Parasa lepida*):—These are long, stout and green with blue stripes. They are usually minor pests which destroy some of the leaves. They pupate in a hard shell on the plants. They are generally hand picked and destroyed. An arsenical spray with calcium arsenate (strength 1 oz. in 2½ gallons of water) is also advised.

5. THE SHOOT WEBBER (*Orthaga exvinacea*):—The caterpillar webs the young shoots and feeds on the green matter. The affected shoots may be cut and destroyed.

6. NUT WEEVIL (*Cryptorhynchus* sp) :—The grubs develop inside the young fruit. The grub bores to the nut and feeds in-

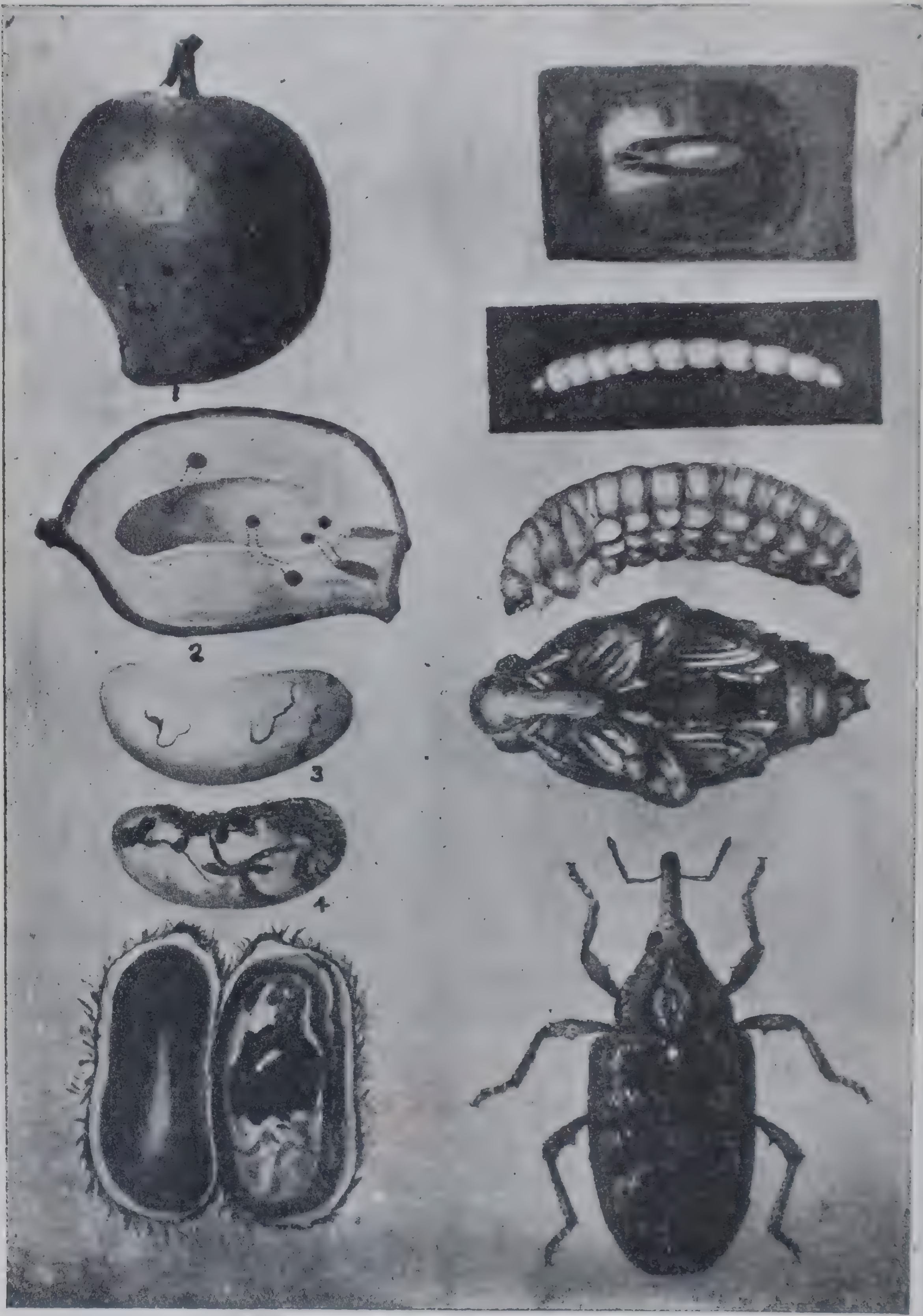


Fig. 47. Mango pests. (Nut weevil in different stages of growth and attack) (Courtesy of the Govt. Entomologist, Coimbatore).

side. The adult weevil comes out discolouring or softening the pulp at the time of fruit ripening. This pest probably affects only certain varieties. The only remedy known is to burn the affected stones and avoid dumping the culls in the mango groves.

7. RED ANTS (*Oecophylla smaragdina*):—These do not cause any damage to the trees but are a source of considerable nuisance to orchard labourers. They also may distribute scales and mealy bugs. The nests may be clipped off in the early stages. Spraying D.D.T. on the scales and mealy bugs is sometimes suggested. Dusting the nests with 5 per cent. Gammexane powder is also said to be effective.

8. MITES TETRANYCHUS AND ERIOPHYD :—The tetranychus mites give a rough powdery surface to the leaves, especially of young trees, which later on turn brownish and become dotted with unsightly scab-like patches. The eriophyd mites cause smoky discolouration on tender shoots and fruit rinds. Dusting with flowers of sulphur may be done.

9. GALLS :—These appear on leaves and produce an unsightly appearance. Defoliation of affected leaves and burning them should be done.

DISEASES

1. MANGO POWDERY MILDEW (*Oidium mangiferae*):—The disease chiefly affects the blossoms. These are coated with an ashy white powdery growth of the fungus. As a result of infection the flowers dry up and are shed. Sometimes the fungus spreads to the stalks and leaves, and the latter become distorted. In certain years this disease causes serious damage. It is easily overcome by dusting the blossoms with finely ground sulphur soon after flowering. It may be necessary to give a second application after an interval of about a fortnight. The operation must be thorough, and fine sulphur (passing through 200 mesh sieve) should be used. Bordeaux mixture (3 lbs. quick lime, 3 lbs. copper sulphate and 50 gallons water) may also be sprayed just before the flowers open.

2. ANTHRACNOSE (*Colletotrichum gleosporoides*):—This fungus attacks the tender portions of the plant twigs, leaves, flower stalks, flowers and fruits. On the twigs the disease appears as small black spots. Dark brown spots develop on the leaves also. Young leaves wither and dry up. Flowers and flower stalks are also affected; and if rainy weather prevails during the flowering

period most of the flowers turn black and drop down, and fruit set is interfered with. Fruits of all ages may be infected and young fruits may be shed. Black spots develop on older fruits and these increase as maturity approaches. Fruits may also rot in storage. Only some varieties are susceptible to this disease. Anthracnose is controlled by spraying the trees with Bordeaux mixture (3-3-50). The first spraying is given before the flowers open. Two or three additional sprayings may be necessary at intervals of a week or ten days. But if the weather conditions are favourable for the disease (such as a rainy period at the blossoming time), spraying may not be of much use. Fruits must be hand picked and care should be taken to see that no wounds are caused. They must be spread evenly in a well ventilated room during the storage to prevent storage rot.

3. SOOTY MOULD (*Capnodium mangiferum, Capnodium ramsoum* and *Meliola mangifera*):—A black growth of fungus develops on the leaves, twigs and sometimes on fruits. The whole tree may present a black appearance. The fungus does not take its food from the plant but from the sweet secretions of some insects already present on the leaves. But it indirectly affects the plants by interfering with the normal functions of the leaves. The remedy for this disease lies in the destruction of insects that supply food for the fungus. If it is desired to get rid of the fungus growth after destroying the insects, the plants may be sprayed with a very thin starch paste made by boiling flour in water.

4. PINK DISEASE (*Corticium salmonicolor*):—The symptoms are found on the branches which begin to wither and die. On the surface of the bark of affected branches a pink coating of fungus growth is visible. This fungus enters the tissues through wounds. The diseased branches are pruned off and the cut surface and the bark painted with Bordeaux paste. All wounds on the stem must be similarly protected. The prunings must be destroyed by fire. One spraying of the branches with one per cent. Bordeaux mixture also helps to destroy the parasite sticking on the bark.

5. BLACK STEM (*Rhinocladium corticolum*):—This is a very minor disease and does not cause much harm. On some of the branches a black felt-like coating of the fungus is visible.

6. RED RUST (*Cephaleuros virescens*):—This is an algal disease. Round reddish growths of the algae appear on the

leaves. This disease is present only in places with heavy rainfall.

7. Root disease :—Plants growing under unfavourable soil conditions sometimes wilt and die. On the roots of such plants various fungi have been observed, chiefly Diplodia. The chief cause of death in most of the cases is lack of good drainage. In extensively ill-drained patches, bad crinkling of the edges of leaves, absence of new growth and gradual die-back of the plant result. When ill-drainage is limited to small patches near the tree, drains may be provided, and these may start from the edge of the original pit in which the tree was planted and may lead to a pit in between the tree rows. The pit should be at least one foot deeper than the drain, which also should have a steep slope from the tree towards the pit. The drain may be packed with boulders or broken tiles or brick pieces up to nine inches from the soil surface ; and over these the ordinary garden soil may be spread. In other cases the drainage may be improved by digging channels, three feet deep and one foot wide between the rows of trees.

8. Loranthus :—This is a parasitic flowering plant found growing on mango trees in neglected groves. These plants spread on the surface of the stem and send in suckers into the stem through which they absorb food materials from the tree. The branches on which these grow must be cut off some distance below the place of attack.

Hints for preparing Bordeaux mixture :—Dissolve 3 lbs. of copper sulphate in 25 gallons of water in a wooden barrel. Slake 3 lbs. of quicklime in a second vessel using a small quantity of water. After the lime has completely slaked, add more water to make up the solution to 25 gallons. Now pour the two solutions simultaneously into a third wooden barrel, stirring the mixture all the while. Before filling the sprayer, the mixture is strained through a strainer. The mixture should be used as soon as possible after preparation on the same day. Test the mixture by dipping a knife in it for some time, when no copper deposit must be formed on the blade. If there is a deposit, add more lime solution. Do not use zinc or iron vessels. The proportion of ingredients may be altered as the case may be.

Bordeaux paste :—Dissolve one-half pound of copper sulphate in one-fourth gallon of water and slake separately one pound of quicklime with one-fourth gallon of water. Mix the two solutions. The resulting paste is known as Bordeaux paste. If a thicker paste is wanted, reduce the quantity of water.

List of References

1. Naik, K. C.—Studies on Propagation of the Mango, Indian Journal of Agricultural Science, October, 1941.
2. ,, Orchard Efficiency Analyses in Mango and Sweet Oranges, Madras Agricultural Journal, March, 1940.
3. ,, and M. Mohan Rao—Cropping Behaviour in Mangoes, Madras Agricultural Journal, July, 1941.
4. ,, and M. Mohan Rao—Some Factors Governing Fruit Bud Formation in Mangoes—Studies on Certain Aspects of Growth, Madras Agricultuarl Journal, October, 1942.
5. ,, and M. Mohan Rao— Relation between Growth and Flowering in Mangoes, Madras Agricultural Journal, November, 1942.
6. ,, and M. Mohan Rao—Blossom Biology and Pollination in Mangoes, Indian Journal of Horticulture, December, 1943.
7. ,, Promising Fruits, Villagers' Calendar & Guide, Madras, 1945.
8. ,, Vegetative Propagational Methods and their relation to Tree Performance in the Mango, Indian Journal of Agricultural Science (In Press).
9. ,, Top-Working of Inferior Mango Trees, Leaflet No. 100, Madras Department of Agriculture, 1942.
10. ,, and S. R. Gangolly—A Monograph on Classification and Nomenclature of South Indian Mangoes (In Press).
11. ,, South Indian Mangoes, Bull. No. 24 of the Madras Agricultural Department, 1941. (Revised Second Edition, 1948).
12. ,, Some Useful Orchard Equipments Devised at Kodur, Madras Agricultural Journal, March, 1940.
13. ,, Standardisation of Mango Culture in India, The Punjab Fruit Journal, Vol. I, No. 1, 1937.
14. ,, The Choicest Fruits of India, Gardener, Vol. II, No. 2, 1938.
15. ,, Future of the Indian Mango Industry, Madras Agricultural Journal, Vol. XXVI, No. 6, 1938.
16. ,, Hints on the Planting of Fruit Trees, Leaflet No. 18, Madras Agricultural Department, 1943.
17. ,, Purchase of Mango Grafts, Villagers' Calendar & Guide, Madras, 1943.

18. Naik, K. C.—Fruit Personalities—Mango, *Mezhichelvam* (In Tamil), 1945.

19. ,, Mango Necrosis (Brick Kilns in Mango orchards, In Hindi), *Kisan,* Patna, Vol. VIII, No. 4, 1934.

20. ,, Mango Propagation Methods at Fruit Research Station, Kodur, Indian Farming, Vol. VIII, January, 1947.

21. ,, Mango Hybridisation, Indian Journal of Agricultural Science (In Press).

CHAPTER II

CITRUS FRUITS

Few fruits have been improved and developed commercially by research to such a great extent as citrus, and few have extended to new regions to create important source of national income and health in as short a time as this group of fruits. Although primarily originated in the tropics, their greatest commercial importance has been attained in areas lying outside the tropics. Within living memory, citrus has extended from practically an insignificant crop in the United States of America to the leading commercial fruit of that country occupying over 650,000 acres. Brazil, Spain, Italy, China, Japan, Palestine, South Africa and Australia are other countries which reckon the citrus as a leading source of national income. As a good source of vitamin C content and as a fruit generally of high healthful food value, citrus fruits have been gaining increasing popularity even in lands far removed from the points of production.

Production and Acreage :—The area under citrus fruits in India has been estimated at a slightly over 130,000 acres in 1943, representing about 6.5 per cent. of the total area of 2 million acres under all fruits in the country. According to the figures available from the Marketing Section, Madras, the Presidency of Madras is estimated to possess an area of over 46,000 acres under all citrus, comprising of roughly 15,000 acres under sweet oranges, 16,600 acres under limes, 8,000 acres under loose jacket oranges, 5,000 acres under Vadlapudi oranges, and 1,400 acres under other types of citrus. The total estimated annual production of fruits in tons is of the order of 21,000 of sweet oranges, 39,500 of limes, 10,400 of loose jackets, 15,300 of Vadlapudis and 3,500 of other groups. The average exports outside the province per annum have been estimated between 1,000 and 1,300 tons of sweet or tight-jacket oranges and about 4,200 tons of limes, while the annual imports average roughly to 6,500 tons of loose jackets from the Central Provinces, Mysore and Coorg. From the point of acreage and production of all citrus fruits, the presidency is ranked as the leading citrus producing region in the country, with about 25 per cent. of the total citrus acreage in India and Pakistan put together. The progress of extension of the area under these fruits can be roughly gauged from the fact that the area in Madras presidency doubled itself in the decade 1921-'22 to 1931-'22 and

PLATE III. VIEW OF A CITRUS GROVE

(Courtesy of Fruit Research Station, Kodur)

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quadrupled itself in 15 years. Coorg with well over 10,000 acres, almost entirely under loose jacket oranges, Mysore with about 15,000 acres mostly under loose jackets and to a small extent under lime, and Cochin and Travancore with a total area of about 600 acres together, give South India the premier rank with very much more than one-third of the total citrus area in the Indian Union concentrated in the region.

CLIMATE

The production of sweet oranges seems to be largely favoured by the dry or arid conditions prevailing during a good part of the year on the plains of South India, such as those prevailing in Cuddapah, Kurnool and Chittoor districts of Rayalaseema and in the Northern Circars. On the other hand, the loose jacket oranges seem to prefer slightly higher elevations and tracts of higher relative humid atmospheric conditions, as in most parts of Coorg, Wynad tracts of Malabar, Agency tracts of Vizagapatam and East Godavari districts, lower slopes of Palnis in Madura, and parts of the Nilgiris and Yercaud Hills, as well as in parts of Mysore State possessing similar conditions as those prevailing in Kadur district. The Vadlapudi orange is found to flourish largely in Guntur and Kistna districts, which have a rigorous summer and low atmospheric humidity, both of which seem to promote quality in the summer harvests of this fruit. The lime production is found to be more adaptable to the plains of South India, preferring the frostless, hot and arid plains to the humid regions or the rigorous winter conditions of Northern India. Lemons are found to be even more adaptable, since they thrive both in humid and dry tracts as well as on the plains and on higher elevations up to about 4,000 feet. Pummeloes and grapefruits can be ranked with lemons in their climate preferences, although the latter seem to prefer drier atmospheric conditions for high yields. Citrons resemble the pummelo, while the kumquats go with the lemons in their adaptability to climatic conditions.

Although temperature and altitude have largely influenced the distribution of citrus production in South India, a closer analysis of the climate in the producing centres seems to show that atmospheric humidity has also a vital bearing. The concentration of successful production of loose jacket oranges under semi-shade or in humid and heavy rainfall areas, as well as their failure to yield profitable harvests in the drier parts of South

India lends force to the foregoing statement. The performance of sweet oranges also is greatly affected by atmospheric humidity and heavy rainfall, but in a different direction. They are found at their best on the drier plains, while under the humid situations and on higher altitudes as those on the Wynad, Lower Palnis and Coorg, the fruits become almost insipid, though juicy ; and the trees are subject to the attack of live parasites such as lichens and loranthus. The fruit quality with Vadlapudi oranges also reaches the highest level where high atmospheric humidity does not tamper the high summer temperature. Pummeloes, grapefruits, and citrons form a group which is not known to be materially affected in respect of yields or fruit quality when grown in either humid or dry situations.

It has already been noted that atmospheric humidity affects the fruit quality especially in sweet oranges. Thinner and smoother skinned fruits with more juice are usually associated with an atmosphere of high humidity and rainfall than with the drier region, though taste may be relatively superior in the latter case. Fungus and bacterial diseases may also be relatively more in humid regions than in drier areas.

Notwithstanding the influences of rainfall, humidity and altitude, temperature as a determining factor in limiting citrus production, can never be over-emphasised. It has been shown by several workers that slight variations that occur in temperature between regions or even sites situated only a short distance apart, have an important influence in the season of blooming, the period required from fruit set to maturity and in the production of off-season crops. As compared to the temperate zones and the conditions prevailing in North India, the blooming season in the more tropical plains of South India is not definite or regular, which is reflected by the production of more than one crop in a year.

SOIL

A loamy soil of good fertility and of uniform texture to a depth of about eight feet is considered ideal for citrus. In shallow and rocky soils as those met with in parts of Yercaud, trees may grow and crop well for a few years, but later show symptoms of decline with die-back, especially after yielding one or more good or heavy harvests. High water tables of a permanent or fluctuating nature are very destructive to the tree life or performance. The trees under such conditions are subject either to root rot or to sudden collapse. Where soils are of varying textures, with open surface layer super-imposed over stiffer layers below, growth becomes unthrifty, and root rot and die-back soon make their appearance. Many orchards of citrus in low-lying sites or under tanks and subject to water stagnation during heavy monsoonic weather, face the risk of being severely damaged by fruit shedding or root diseases. These various instances go to show that citrus trees are among the most sensitive of crops to adverse soil conditions.

Much loss has also occurred in the past by selecting soils with certain deficiencies of food elements or excess of these. Similar losses may also occur by the unsuitability of irrigation water, which should never be used if suspected to contain high concentrations of soluble salts, particularly in the form of chlorides. Opinion of the chemists, based on actual analyses of water, will be helpful in avoiding future losses, if obtained prior to the selection of sites. Excess of calcium carbonate is also a frequent cause of uneconomic citrus orchards. A pH range between 5 and 8 is considered to be the optimum for sweet oranges. This range of pH denotes a soil either neutral in reaction, or slightly acidic or alkaline in nature. Possibly a slightly lower pH indicating more soil acidity may be tolerated by the loose jacket oranges, which are usually grown in Coorg, Wynad, Nilgiris, and such humid situations ; but the range of safety is not expected to be lower than 4 pH. Alkaline soils with a pH over 8 have been found to cause not only several deficiency and root diseases but also lead to unthrifty appearance and delayed bearing. Testing of the soil pH or degree of acidity or alkalinity is therefore essential on sites to be devoted to citriculture as a commercial proposition. In a separate section of this chapter the subject of deficiency diseases will be dealt with, and that will serve to further emphasise the value of soil analyses.

Low water table and efficient orchard drainage have often been found to make all the difference between success and failure even in soils otherwise suitable. The early decline of sweet and Vadlapudi oranges in large stretches of the deltaic areas in the southern parts of the Circars has been found largely to be due to high water table and inadequate drainage. The decline of Batavian orange growing in Palacol area, the reduction in Vadlapudi acreage in parts of Kistna, Godavari and Guntur districts and the extremely short life of Musambi and Sathgudi orange near Siruvel in Kurnool district are all due to these adverse soil features. Any site which is subject to the rise of water table at any time of the year within about six feet from the soil surface or which is possessed of a sticky sub-soil layer within six feet depth, such that would remain saturated for prolonged period in wet weather, should be rejected as unsafe for citrus plantings. Limes are perhaps the most resistant to ill-drained or wet soil conditions, but even these are better raised in soils free from the danger of high water table or ill-drained conditions.

CLASSIFICATION AND VARIETIES

There has been a great deal of confusion in the classification of citrus, caused by the adoption of varying standards by citrus taxonomists. The latest treatise on " The Botany of Citrus and Its Wild relatives of the Orange sub family " by Walter T. Swingle of the University of California, representing the results of a study extending to well over 40 years by that author, should serve to set at rest the doubts so far entertained on the subject. According to that classification, the South Indian cultivated *Citrus* fall under the following species :

1. Sweet orange—*Citrus sinesis,* (Linn) Osbeck.
2. Mandarin, tangerine or loose skinned orange—*Citrus reticulata*, Blanco.
3. Lime—*Citrus aurantifolia*, Swingle.
4. Lemon—*Citrus Limon,* (Linn) Osbeck.
5. Pummelo—*Citrus grandis* (Linn) Osbeck.
6. Grapefruit—*Citrus paradisi*, Macfayden.
7. Citron—*Citrus Medica,* Linnaeus.
8. Kumquat—*Fortunella* sp. Swingle.
9. Sour and Bitter orange—*Citrus Aurantium,* Linnaeus.
10. Hybrids.

The last group of hybrids seems to comprise of a plentiful number of South Indian forms, due to accidental hybridization that has been going on for centuries in the exclusively seedling plantations till very recently. Swingle does not agree that these hybrids can be accorded ranks of true species, since some of these complex hybrids have little or no chance of survival in Nature, and some of them may be only the auto-tetraploid forms of the parent species generally with thick rinds, thick leaves, large oil glands, with less juice and larger seeds than the diploid form of the parent species.

These hybrids owe their existence to man's efforts to perpetuate them by vegetative means or through nucellar seedlings. There is no proof that all such chance seedlings discovered and propagated by man can persist and become established as wild species. On the other hand, mutations that frequently arise in *Citrus* and are propagated usually by vegetative means deserve to be given the status of a clone or horticultural variety and not that of a species. The practice of calling a chance seedling, mutation, or hybrid, which can be perpetuated by budding or grafting, as a species is prevalent in ornamental gardening, but such false or "garden species," as they are called, are not true species in the taxonomic sense ; for unlike the Linnean species which though continuously crossing with one another keep within the limits of definite specific characters, some of the above "garden" species being seedless cannot reproduce themselves sexually and can only be multiplied as clones. On these several grounds, the species rank previously accorded to some South Indian Citrus by Tanaka, such as *Citrus maderaspatana* for Vadlapudi orange and kichili and *C. pennivisiculata* for gajanimma have to be replaced by designating these forms as hybrids.

In keeping with the definition that a variety in horticulture is a group of individuals possessing the same characteristics, and have been perpetuated or multiplied from one parent by asexual methods, and supposedly possessing the same genetic constitution, while mutations arising from a parent and possessing a changed genetic constitution produce new varieties, the descriptions of the following varieties of South Indian *Citrus* are listed. The horticultural varieties are also often designated as clones, but this term is more appropriately used to the vegetative progeny of a single individual and which are therefore considered as parts of that individual.

In *Citrus*, the varieties sometimes are so much alike to each other that they are ordinarily indistinguishable ; yet they may differ in such characters as average number of stomata per unit area. Many varieties differ between themselves only in maturity season, smoothness of rind, juiciness, flavour, thornlessness etc. The difficulty in distinguishing such small differences has led to considerable confusion in *Citrus* nomenclature.

C. sinensis—SWEET ORANGES :—Fruit medium-sized, peel orange coloured, pulp sweet, petioles narrowly winged, pulp adhering to the peel, seeds polyembryonic. This is the most popular species of *Citrus*, eminently suitable for consumption as fresh fruit or in the form of juice. They are usually divided into three groups (1) those that predominantly bear normal fruits, (2) those yielding very largely fruits with navels opposite the stalk end and (3) those with red or red-streaked flesh. The first of the groups is of the greatest commercial importance in South India, claiming nearly 10,000 acres under it.

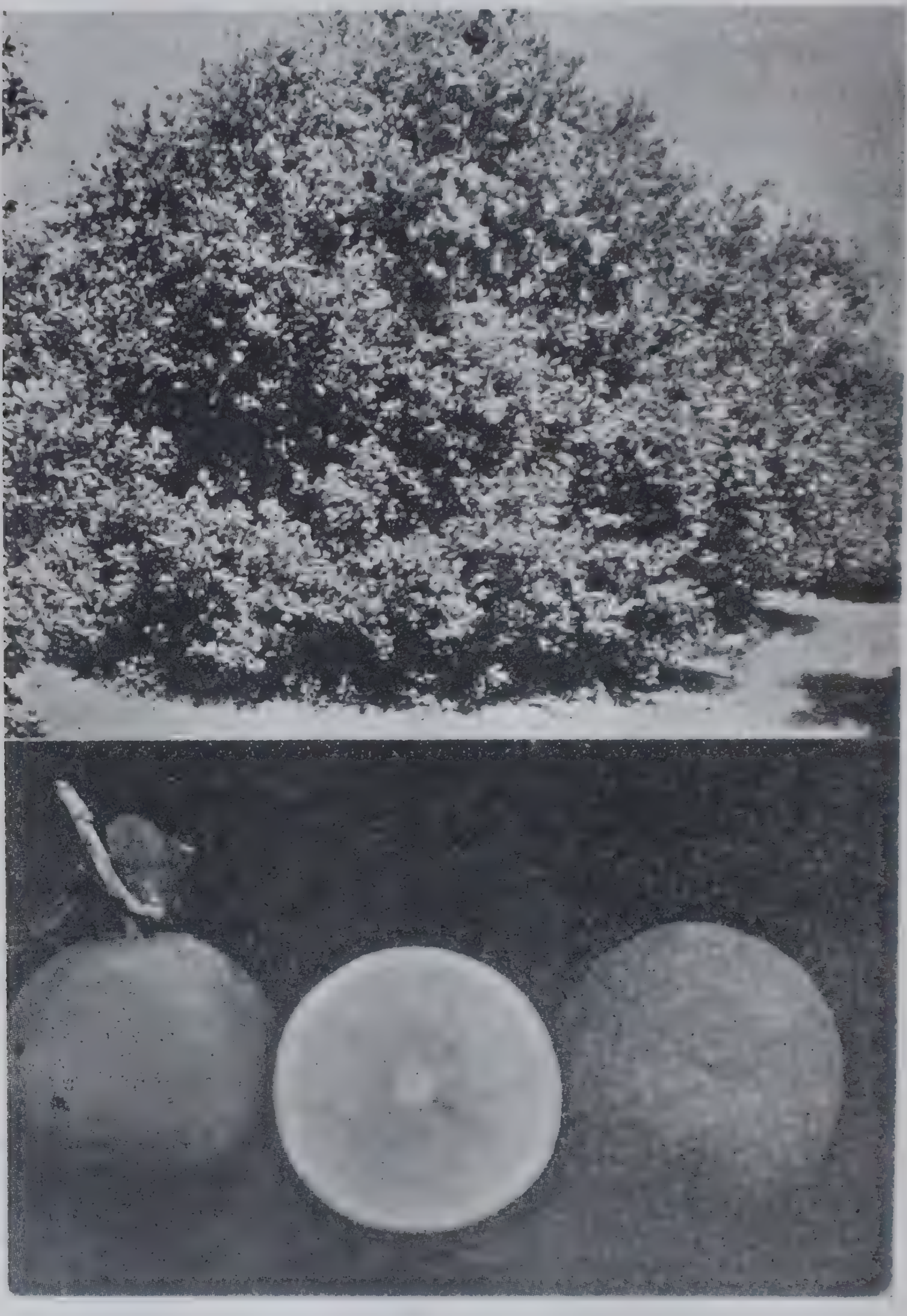

Fig. 48. Sathgudi orange.

Sathgudi, also called as Chinee orange, is the most popular and extensively grown variety of sweet orange occupying an area of over 4,000 acres in Cuddapah, about 1,000 acres in Chittoor and about 700 acres in Kurnool districts. Recently the variety has spread to almost all parts of the plains in South India excepting on the higher elevations and the West Coast, and more particularly to Madura and Tinnevelly districts in Tamilnad and to many parts of the Circars. It is a fruit with smooth surface, almost spherical in shape, small to large in size and attractively orange coloured when fully mature from November to February. The base and apex are evenly rounded. The peel is varying in thickness with inconspicuous oil glands. The mesocarp is light yellowish-white, segments usually 10 to 12, with membranes and rag of varying texture and with orange coloured pulp. The best specimens are thin skinned, thin peeled with very little rag, abundant juice and excellent flavour. Seeds are few to many. The tree is a vigorous grower, with blunt and stout thorns, narrowly winged leaves, white and sweet scented petals, hollow fruit core and white cotyledons. It matures the main season fruits from October to February. Being largely seed propagated, there are large variations in fruit size, shape, rind thickness, rag texture, juiciness, seed content, flesh colour, and in eating quality including flavour. The variety first gained prominence in the village of Sathgur in North Arcot district, from where it spread to Karvetnagar and Nagari side in Chittoor district and later to the Rajampet Taluk of Cuddapah district around Kodur, where it has attained the greatest commercial importance. The name Sathgudi is believed to have been derived from Sathgur village, while in Madras market the fruit also often passes by the name of Nagari or Kodur Sathgudi or Chinee, the last name being probably associated with the sweetness of the fruit (*Chinee*—standing for sugar). Being one of the most remunerative fruits, yielding heavy crops in many parts of the province, it is rapidly spreading to new areas. Stray trees grown even on higher elevations as those of Nilgiris up to about 4,500 feet from the sea level as well as in humid regions as in Coorg have been found to be very prolific, though lacking colour and flavour. With the popularisation of budding and of selected parental progenies as clones, Sathgudi has a big future in South India, especially in the irrigated sections of drier or less humid regions.

Next to Sathgudi orange, the Batavian orange has attained the largest commercial importance in South India. It is almost exclusively confined to the Northern Circars, with over 2,000 acres devoted to it. The most concentrated area under this variety of sweet orange is found in and around Dosakayalapalli in East Godavary district. The variety can hardly be distinguished from the Sathgudi, except in rind colour which is light yellowish-green, usually with pale yellow patches on the green rind, in the case of the Batavian. In respect of eating quality also, it is inferior to the Sathgudi, although a few excellent specimens may occasionally be met with on this predominantly seed propagated variety also. The name of the variety seems to have been derived from its supposed introduction from Batavia. At the beginning this variety was very popular in and near Palacole in East Godavary district, which was one of the early Dutch settlements. Like the Sathgur village, Palacole has ceased to count sweet orange as an important commercial crop, even though both the varietal names are yet associated with their initial trial grounds.

The third important sweet orange variety of South India is the Mosambi, also called as Mussambi or Muzambique orange. It differs from the above two varieties in having prominent streaks on the rind and a circular grove at the stigma end, the former of which gives it a rough exterior. It is also more difficult to peel and contains more seeds. Though sweet, it is sometimes almost insipid, owing to lack of flavour and an inadequate blending of acidity with sugars. It claims an area of less than 150 acres, being restricted mainly to parts of Kurnool district, bordering the Hyderabad State.

A large number of other varieties have been introduced and tried in different parts of South India including the representatives of navels, blood red oranges and other smooth skinned orange groups. Of the first, the Washington Navel orange has accounted for the largest attention, the plants having been mostly introduced from Australia. Excepting for a limited success for a few years only in a few orchards near Bangalore, this variety has uniformly failed to thrive under South Indian conditions, its performance being erratic and the fruits largely being of a coarse, thick-skinned and flavourless type. Of the navel varieties which have given some promise at Kodur is the Buckeye Navel, which is characterised by very high yielding tendencies with fruits of good quality and therefore worthy to be watched further. None of the blood red oranges tried at Kodur developed their characteristic flesh colour till the time of their harvest. Among the smooth skinned or normal sweet oranges, the Valencia Late seems to have some promise as a fairly prolific variety yielding fruits of good quality ; but contrary to its reputed late maturing character, it fails to retain the crop on the trees till after the normal harvest season. Delayed harvests are reported to have produced at Penagalur pithy and insipid fruits. The Jaffa orange and the Malta group of oranges from North India have also failed to show any encouraging performance or fruit quality. Taking all the known facts into consideration it seems safe to recommend for South India the Sathgudi and Batavian oranges for extensive cultivation, provided the plantations are stocked with vegetative progenies from selected trees of merit.

C. reticulata (Mandarin, tangerine or loose skinned oranges) :—Fruits with peel adhering loosely to the pulp, usually sweet, flowers usually perfect, petioles with narrow or broad wings, seeds small, embryo green.

The names mandarin and tangerine are often used interchangeably, but the latter name is more generally applied now to varieties which produce fruits of deep orange or scarlet rind colour. Being a cheaper fruit than the sweet orange and having a sweeter taste with a flavour peculiar to itself, the loose skinned orange has a wide appeal to the public in South India as a dessert fruit. This fruit is extensively planted in Coorg, parts of Mysore State, Wynad tract of Malabar and the Nilgiris, parts of Shevroys and Palnis, and in several other humid or heavy rainfall tracts of Madras presidency. The area in Coorg is well over 10,000 acres at present ; in Mysore State it is estimated at over 1,000 acres, while in Madras presidency the total area is about 8,000 acres, with about 6,000 acres in Malabar and Nilgiris, 1,000 acres in the Lower Palnis of Madura district and 500 acres in Yercaud Hills of Salem district. There are several distinct groups of loose skinned oranges, separated from each other either by tree shape, nature and spread of branches etc., or by fruit characters such as rind colour, shape, size etc. It is common to refer to all loose skinned oranges as santras in many parts of India. Like the Malta among the sweet oranges, santra is a group name and cannot be strictly applied to any single variety, as is often done. Till the existing taxonomic confusion is unravelled, it is difficult to assign the correct nomenclature to all the varieties of loose skinned oranges under cultivation in South India. The existence of a large number of hybrids, due to the spontaneous origin as chance seedlings in the numerous seedling orchards, makes the study of nomenclature and classification difficult. From a reference to the recorded descriptions by Swingle and Webber, it seems that the loose skinned oranges grown in South India fall under any one of the following varieties or groups.

1. King orange :—Fruits are of deep orange yellow colour, surface rough and bumpy, shape oblate to spherical, base rounded to somewhat necked, and wrinkled or furrowed, stem insertion slightly sunken, apex flattened or depressed, rind thick, and easily removed and rarely baggy, oil glands large, axis large, hollow and stellate, segments 10 to 12 and easily separating, rag little, pulp dark orange, tender and melting, vesicles medium in size, flavour rich and sprightly, seeds many, plump and beaked, cotyledons white, tree upright, erect, thorny or thornless, foliage comparatively open, leaf apex a rounded point, and frequently notched, petioles medium sized and narrowly winged.

2. Satsumas :—Fruit orange coloured, surface smooth or slightly rough, in some becoming bumpy or furrowed, shape oblate to spherical, base necked or depressed, apex smooth, flat or slightly depressed, rind thin, tough and leathery tending to make the fruits keep well, oil glands large, axis hollow and small, pulp orange or salmon coloured, tender and melting, vesicles short and broad, flavour sprightly, some varieties seedless, seeds beaked, tree small or dwarf and spreading, nearly thornless, leaves tapering at the apex and base, petiole slender and long and very slightly, if any, winged.

3. Other Mandarins :—Emperor is the most well known variety of this group but found little in South Indian orchards. Fruits are pale orange in colour, oblate in shape with necked base, rind moderately thin, easy to peel, segments irregular, pulp orange coloured, seeds many, long and pointed.

4. Tangerines :—Dancy is the most well known in this group. Fruit is deep orange red to scarlet, surface smooth and glossy, shape oblate to pyriform, base slightly or markedly necked and more or less corrugated, apex broadly depressed, rind thin, tough, loose and easily removed, oil glands small, axis large and hollow, segments usually regular and easily separating, rag little,

pulp dark orange and tender, vesicles short and broad, flavour sprightly, seeds many, small, short and blunt or beaked, cotyledons greenish. Tree is large, nearly thornless, branches erect when not loaded with fruit, leaf apex tapering to a point or rounded, petioles medium and very slightly winged. Ponkan is a famous tangerine variety of China, stated by Tanaka to resemble some santras of India. Its fruits are cadmium orange coloured with smooth surface and globose to oblate form, base flattened or somewhat necked, axis very large and hollow, pulp bright coloured and almost salmon orange in colour, vesicles large, plump, angular, and never becoming parallel to each other, pulp aromatic, sweet and excellent, seeds few, small and plump with base generally beaked. Cleopatra is another variety which is found in South Indian orchards. It has fruits of dark orange red in colour, oblate in shape and flattened at both ends. The size is small, too small to be of commercial value. It has also numerous seeds. Trees are low, spreading and ornamental. It has been tried on a small scale as a rootstock at Kodur.

Whether the loose skinned orange grown so largely in Coorg and Wynad as well as elsewhere in South India belong to the santra group and is a true Ponkan, as claimed by Tanaka and not accepted by Webber, it is premature to say. There is no doubt, however, that the Kukal orange of some parts of the Nilgiris is a distinct variety from the oranges grown at Kallar and in Wynad. The name of Coorg orange has been previously applied by some authors to the oranges grown in Coorg, Mysore and Wynad, while the Kallar orange, Kukal orange or Kodai oranges have also been used by others to designate the fruits produced in respective regions. Till the taxonomic investigations are completed, it seems advisable on grounds of usage to retain the name santra or mandarin as a group name to all the loose skinned oranges of South India, adding the local or regional names to distinguish the fruits from different tracts. The forms or varieties as typified by Kukal or Coorg oranges are both valued for quality and for good orchard performance; and their extension on suitable sites in humid regions of South India seems very desirable, especially as the region is dependent at present on the imports of this fruit from the Central Provinces to an extent.

C. aurantifolia—LIMES :—Fruits are small, pulp acid and adhering to the skin, petioles with medium sized or narrow wings.

seeds small and smooth with brownish red chalazal caps, peel usually yellowish green. For fresh fruit beverage in the form of a *sherbat* and for domestic or culinary use, lime has long been a very popular fruit in South India. Recently it has achieved considerable importance for manufacture of bottled squashes and cordials. With a total acreage of nearly 17,000 in Madras Presidency, the production of this fruit in the province has become surplus to its requirements, so that over 4,000 tons are normally exported outside South India. The production in South India roughly amounts to much more than half of the total production in India, and there seems still scope for extension, as conditions are not as suitable in other parts of the country for its culture because of the entire absence of frost in the South. Excepting for a small area of about 300 acres in Mysore and about 50 acres in Coorg, the South Indian production is mainly restricted to parts of the Northern Circars, Rayalaseema and the districts of Madura, North Arcot and Tinnevelly. In the Circars the principal areas of production are in Godavary, Kistna, Guntur and Nellore districts, while in Rayalaseema, Cuddapah and Chittoor are the main centres.

The ordinary acid lime, or as it is called elsewhere in India as the Kagzi lime, is a small, slender, bushy tree with fine twigs and leaves, stiff and sharp thorns, and producing large crops of acid fruits with thin rinds. The leaves are almost wingless or are narrowly winged. The flowers are white and non-scented. The juice sacs are slender and spindle shaped. The core is solid, and the seeds are green when cut. This variety accounts practically for the entire commercial lime production in South India. From a survey of some of the lime orchards, it has however been observed that several other forms of limes also are found as stray trees in private orchards. One is a small, roundish oblate fruit with smooth and shiny rind and with inner partitions fairly visible from outside the skin. It has a slight mamilla and pale green flesh. Another form has similar fruits but without mamilla. Yet another hybrid form bearing red-fleshed pulp has been noted at Madanapalle. These novelties in the group of limes are yet to prove their superiority to the Kagzi.

Tahiti is another large-fruited, large-leaved lime introduced at Kodur and found prolific though less so than the Kagzi lime.

It produces few seeds and the fruits are slightly nippled. It also appears to be resistant to wither-tip disease.

A group of limes producing sweet fruits and possibly of hybrid origin and fairly extensively cultivated in other parts of India under the name of sweet limes, has also been introduced and cultivated on a small scale in South India. The so-called sweet lemons grown in parts of Madura, Malabar, Salem and Nilgiris appear to be also of hybrid origin. The sweet limes and the so-called sweet lemons both have sweet pulp, yellowish orange, or yellow rind, smooth surface or indistinctly lobed, oblate or globose shape, thin skin, plenty of juice, a sweet but insipid flavour and white cotyledons. The tree in both is large and spreading giving the appearance of that of a sweet orange, excepting that the leaves are blunt-pointed and these and the new growths are lighter green in colour. Some of the so-called sweet lemons are occasionally sour or acidic with little or no value as dessert fruits.

C. Limon—LEMONS :—Fruit is small to medium sized, acid or slightly bitterish usually, pulp adhering to the rind, petioles winged very narrowly, flowers perfect and male with abortive ovaries, the latter up to 80 per cent in some varieties, corolla purple, flower not scented, seed white within, and core of fruits usually hollow. Used for the same purposes as the acid lime, the lemon is a fruit of recent introduction in the south of India and has no sizeable production to its credit at present. It has several virtues which entitle it for a greater popularity than that enjoyed at present. The trees yield heavy crops almost from the second year of planting, the individual tree yield of a variety having been 3,173 fruits at Kodur till the ninth year of planting, with 966 fruits in the sixth year. The fruits are about two to three times as large as the ordinary lime and yielding as many times of juice per fruit. Trees also fruit like the lime practically all through the year and are also practically free from canker and wither-tip, which are the common scourges of the lime. They have also shown themselves to be more adaptable than the lime, having produced outstanding performances both in the West Coast as well as in the drier regions of Rayalaseema.

Of the several varieties tried in South India, the following seem to be very promising :

1. SEEDLESS :—This is one of the promising varieties at Kodur having yielded per tree 2,661 fruits in nine years of plant-

ing. The tree is medium sized, vigorous and robust, with spreading and densely packed compact head ; foliage moderately abundant ; spines medium to long and sharp pointed. The fruit is seedless, juicy and oblong oval.

Fig. 49. A lemon tree.

2. Nepali Round :—This is another seedless variety of great promise at Kodur, having produced 1,998 fruits in nine years of planting. The tree is medium to large, vigorous, with drooping compact branches, practically thornless ; the fruit is juicy, roundish with the nipple only as a scar.

3. Italian :—This is another seedless variety, also very prolific with a tree yield of 3,173 fruits in nine years of planting. The tree is large, spreading and thorny ; the fruit is very juicy, roundish oval and seedless.

4. Nepali Oblong :—This is a promising seeded variety, which yielded at Kodur 2,928 fruits per tree in the course of first nine years in the orchard. The tree is medium to large, vigorous with drooping compact branches, moderately spinous with medium thick, sharp pointed, stiff spines ; the fruit is very juicy, oblong and with few seeds.

5. Lisbon :—This variety produces generally robust growth and an upright tree habit. The fruits are smooth with a prominently drawn-out nipple. Compared with the above four varieties at Kodur and with Malta lemon in the West Coast, it is of lesser value in commercial orchards. At Penagalur this variety is reported to have proved inferior to Villafranca and to have been very short-lived, the trees having died in about the tenth year.

6. Eureka :—The fruit differs from Lisbon by having a rougher and a slightly more ribbed surface and a flatter nipple. Eureka trees also are smaller but more spreading. It has not performed at Kodur as well as the first four varieties.

7. Villafranca :—This is similar to Eureka, with trees more thorny and with a little more dense foliage. This variety also has not shown as much promise as the first four varieties. At Penagalur it proved superior to Lisbon, though as short-lived.

8. Malta :—This is a small fruited variety, almost of half the size of the other lemons like Nepali Round or Oblong. Trees have commenced to bear crops in the second year of planting in the sandy areas of the West Coast. The trees are bushy, compact and inclined to be dwarf and the fruits medium, juicy and seeded.

In fruit characters, all lemons resemble each other to such an extent that varietal identification cannot be done with certainty. The seediness, tree growth and performance are the major characters, on which alone a distinction seems feasible to the growers.

Two forms of lemons, one oval in shape and the other elongated are also found occasionally in private orchards, and these go by the name Addanimma, from a tree of which 1,248 fruits were harvested at Kodur in the ninth year. Trees of this are being raised in the province almost entirely by seed. One other variety of lemon having leaves almost similar in shape to the acid lime, but resembling the lemon in other morphological characters, was located by the author in a private orchard in Rajahmundry and is now designated as Rajahmundry lemon. This has performed well at Kodur, giving an exceptionally large yield of 1,991 fruits in five years of planting, with 603 fruits in the fifth year. Unlike the Kagzi it seems very resistant to wither-tip. The tree is also larger than the Kagzi lime and is more spreading, besides producing larger sized fruits like all other lemons. The variety is seeded, though occasionally seedless fruits become available.

The rough lemon or Jamberi (syn. Jamburi) is considered to be a hybrid. It has a sour pulp, a bumpy rind of lemon yellow colour with a prominent nipple. It is used extensively as a rootstock for sweet orange, loose skinned oranges and other cultivated citrus.

The true sweet lemons are not cultivated in South India in so far as is known.

C. grandis—PUMMELOES :—Fruits are very large to large, pulp vesicles large and separable easily, petioles broadly winged, seeds large, usually flat, rough and with only one embryo, peel adherent, seed white within. Nearly 900 acres are said to be devoted to this fruit in South India, but it is mainly as a homeyard fruit rather than as an orchard fruit it is popular in the region. As stray trees it is found all over South India, excepting on elevations exceeding about 5,000 feet. Pummeloes are distinguished from grapefruits mainly by the more broadly winged petioles, larger fruit size, thicker rinds, in having a tough and more solid pulp, monoembryonic seeds and in bearing fruits mainly as singles. The pummeloes have been raised generally in the past by seed, and therefore, exhibit large variations. They are broadly grouped either according to shape, which consists of (1) oblate or globose fruits, flattened or neckless and (2) elongated or pear-shaped fruits with neck ; or according to flesh colour i.e., (1) white or (2) pink. Among the clonal strains under trial at Kodur, the Red and White have given evidence of being suited for extension. Both have pink pith (which fact shows that the name "White" applied to the latter is incorrect) and are of good eating quality. The latter is also seedless. Hawaiian pummelo introduced recently at Kodur is found to be not a true pummelo but a citron.

C. paradisi—GRAPEFRUITS :—Fruits are large, pulp light green, juicy, juice sacs fairly large and coherent, petioles rather broadly winged, pulp adherent to peel, seeds white, smooth and polyembryonic. Though a fruit of great economic importance in some parts of the world, the grapefruit has yet made no appeal to the South Indian palate, its consumption being now limited only to a few persons in urban areas who have developed a liking for its bitterish taste. As a source of healthful and refreshing bottled beverage, it may offer greater possibilities. Of a number of varieties tried in South India, a seeded variety by name Poona and a seedless variety called as Special have shown encouraging performance at Kodur. Marsh Seedless, the well known and almost seedless grapefruit of yellowish colour, Duncan which is similar but seeded, Foster which is pink fleshed and seedy and Triumph which has yellow coloured flesh and is also seeded, have also been grown in different parts of South India with varying results. At Kallar

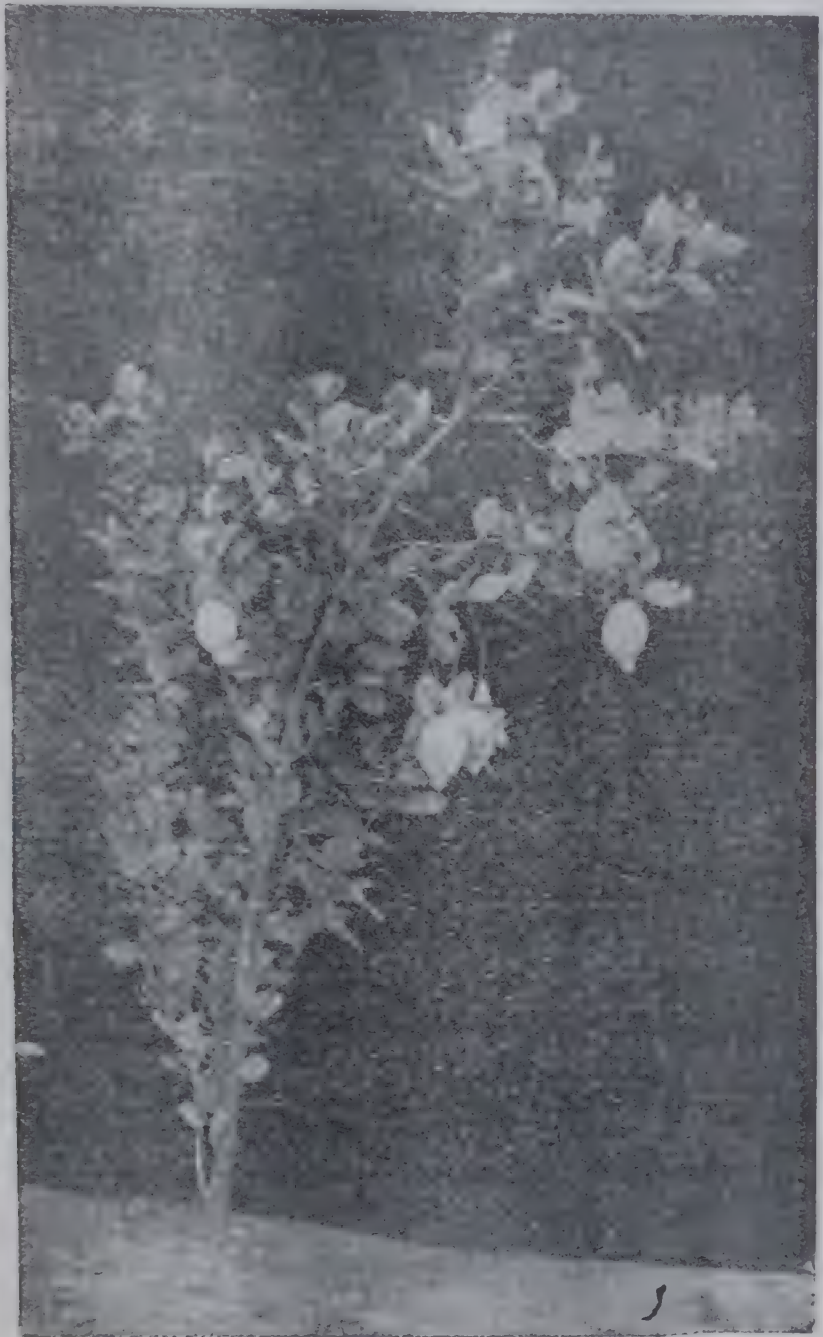

Fig. 50. A citron plant.

Fruit Station grapefruits of Marsh and Triumph varieties have only been producing moderate to low yields, while at Penagalur in Cuddapah, it is reported that the Triumph failed completely, while the Marsh gave high yields of over 1,500 fruits per tree per year. The trees also are said to have grown to a huge size, surpassing those of the other *Citrus.* The Special grapefruit found to give promising performance at Kodur produces large fruits weighing about 1 lb. 8 oz. each, and about four inches long and four inches in diameter. The fruit is roundish, thick skinned (up to about 0.6 inches), lemon yellow in colour and inclined to be warty. The juice is plentiful and of good quality. Marsh Seedless, however, has been adjudged even superior to the Special in fruit quality at Kodur.

C. Medica—CITRONS :—Fruit is large or medium in size, pulp acid, sweet or slightly bitter, petioles wingless, flowers perfect and male, peel thick to very thick, tree small, branches straggling, corolla reddish purple and non-scented, fruit oblong and mamillate, rind soft and warty, juice sacs slender, core hollow, and seeds white when cut. Being mainly used for preparing pickles and for medicinal purposes and to a small extent for making peel candy for use in cakes, the citron has not attained any commercial importance. It is grown mainly in the form of stray trees in home compounds, or in orchards with other fruits. Citrons are grouped into (1) sweet and (2) acid citrons. The fleshy parts of the peel immediately below the outer surface are also sweet in some varieties and can be eaten. Of the varieties tried at Kodur, Mahalung and Bengal citron have given promising performances. The former has sweet peel, while the latter has acidic peel. The Citron of Commerce is another of the promising varieties at Kodur, bearing fruits, each about 6 inches long and 4.5 inches diameter, ovoid to oblong oval, with a broad nipple and persistent style, and a rind of 0.7 inch thick, which is lemon yellow and sweet in taste. The Hawaiian pummelo is a citron and has done very well at Kodur. bearing fruits of exceptionally large size, one weighing as much as 8 lbs. 11 ozs. It is oval shaped, thick skinned, lemon yellow in colour and warty, and has white flesh. It is also very prolific having yielded over 100 fruits in the first seven years.

Fortunella sp—KUMQUATS :—This is not a cultivated frui and is grown in South India mainly for ornamental purposes. Th fruits, however, make a good candy. A prolific and hardy plan producing tiny fruits in very large numbers practically all through th year and with dense foliage, it can be grown both in the orchar and in tubs or large pots. Two main forms, one bearing roun fruits and another with longish, oval or oblong fruits are known The tree has winged or wingless leaves, non-scented flowers, hollow fruit core and white cotyledons.

C. Aurantium—SOUR OR BITTER ORANGES :—Fruits are medium in size, peel rough and scarlet orange, pulp very sour or bitterish, petioles rather broadly winged, flowers sweet scented, fruit core hollow and filled with strings of fibre, seeds green when cut.

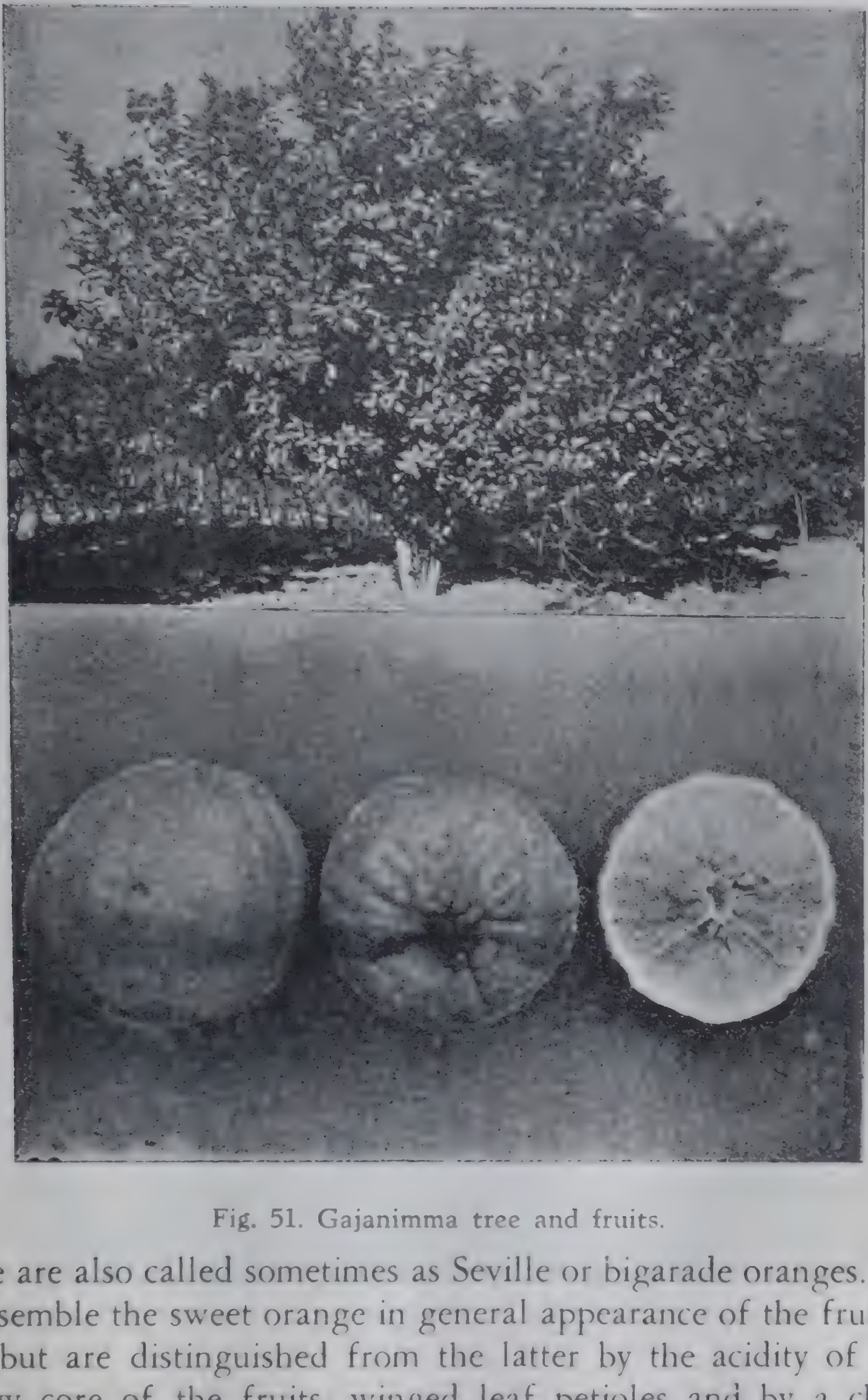

Fig. 51. Gajanimma tree and fruits.

These are also called sometimes as Seville or bigarade oranges. They all resemble the sweet orange in general appearance of the fruit and tree, but are distinguished from the latter by the acidity of pulp, hollow core of the fruits, winged leaf petioles and by a characteristic odour of the crushed leaves and fruit rind. They are also reputed to be resistant to some gum diseases unlike the sweet oranges. Due to this and other reasons, the sour orange has been the most popular rootstock for sweet orange in many parts of the world.

HYBRIDS

1. VADLAPUDI ORANGE :—The cultivation of this is largely confined to parts of the Circars, where it is relished particularly in summer months for its sweetish pulp with an acidic twang and characteristic flavour, both as fresh fruit as well as for a fine sweetened juice made out of it. For squash and marmalade also it has been found suitable. The fruit resembles the loose

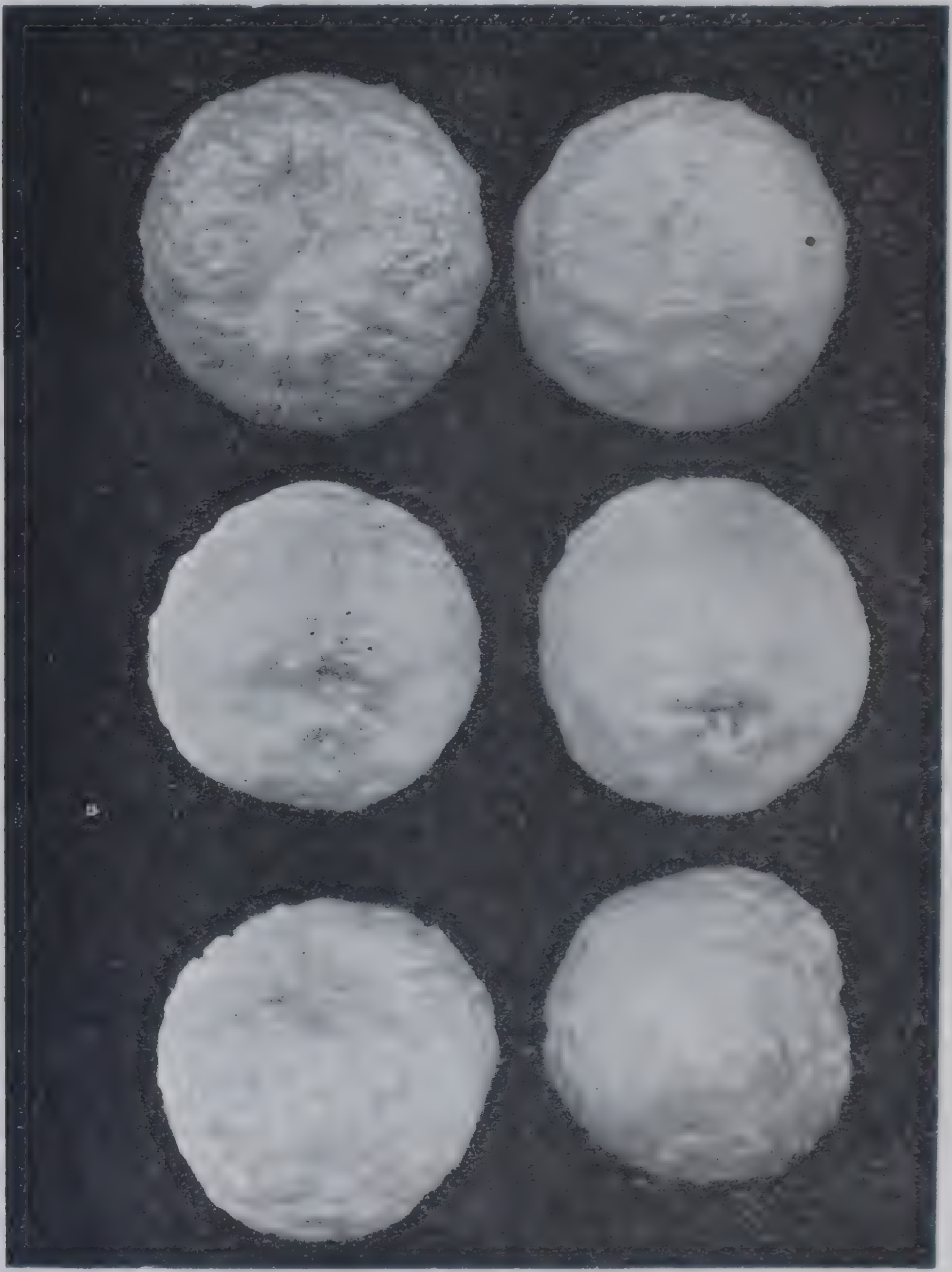

Fig. 52. Kichili fruits

skinned orange but with a more prominently warty surface. Flowers are sweet scented, fruit core hollow and filled with strings of fibre, and seeds are green when cut. The fruit is very acidic except in summer. Though normally white fleshed, a yellowish pink fleshed bud sport has been perpetuated at Kodur with a slightly sweeter taste than the common Vadlapudi. It has also a less warty rind and fewer seeds than the normal Vadlapudi.

2. KICHILI :—This resembles the Vadlapudi in tree and fruit characters, but is rarely sweet in any part of the year. It is grown merely as stray trees in Rayalaseema, where it is found to be very hardy and prolific.

3. GAJANIMMA :—This is said to resemble the Bandhuri of Coorg and Attara of the Central Provinces. The fruit is larger than the Kichili and is mamillate, with less warty and almost smooth surface. It is not necked. It is inedible, but is prolific. The tree is hardy, though as a rootstock it has shown to be highly susceptible to gummosis. The leaf petioles have medium sized wings, petals are purple but non-scented, and fruit core hollow. The seeds are white when cut.

4. BILLI KICHILI :—This is believed to resemble the Cleopatra mandarin. Spines and petiole wings are absent, flowers mildly scented, rind thin and loosely attached to the pulp, is chagrined, and has orange to reddish colour. The core is hollow, and the seeds are green when cut. The tree has slender branches.

PROPAGATION

Seed propagation is the primitive stage with which citrus industries started in all countries. This method has, however, been abandoned now in favour of budded plantations in most advanced citrus producing regions. In South India also there is a distinct trend towards the establishment of budded plantations, especially in the case of sweet oranges. Owing to the production of nucellar seedlings by almost all *Citrus* species and varieties, the seedling trees of these are fairly uniform in quality and orchard performance. With the acid limes, evidence has been gathered at Kodur to clearly demonstrate that the budded trees are not necessarily more uniform in yields than the properly selected seed progenies. A high degree of uniformity is also commonly seen in the loose skinned oranges and citrons; but with sweet oranges on the other hand, seed propagation appears to lead to great variation both in quantitative and qualitative features of orchard performance. In two representative private orchards, planted to seedling Sathgudi trees at Kodur and which were generally deemed to be profitable to the owners, it was determined from a three-year performance study that the unprofitable trees varied from 23.6 per cent. in one to 52.9 per cent. in another. While the maximum tree yields were 1,495 in 1937-'38 in one of the orchards, about 7.2 per cent. of the trees there carried no crop at all or bore fruits less than 50 per tree. Equally large variations have been observed in respect of fruit quality and such fruit characters as shape and size of fruits and thickness of peel. The above results relate to the normal bearing season, but in the off season also there were material differences in the bearing of trees in the same orchard. The fact that sexual propagation often leads to the production of inferior progeny in Sathgudi and possibly in lemons, grapefruits and pummeloes, is a strong argument in favour of vegetatively raised plantations. For the production of standard quality fruits, which is so necessary for the growth of any industry, budded citrus plantations from selected parents are also deemed essential.

It is known that certain citrus varieties are unadaptable to some soils, while others may suit the same conditions. The sweet orange and Vadlapudi seedlings for instance are not accommodating in heavy soils with high water table, as those in the deltas of the Circars, while on the same soils the acid lime thrives. The sweet orange does not also prove profitable in the very infertile sandy soils. It is possible to get over such handicaps by planting budded trees on a rootstock more accommodating to the given soil conditions.

The fact that budded plantations crop at an earlier age than the seedlings is also a point to be reckoned with in commercial citrus production. At Kodur the first bearing in budded Sathgudi trees on certain rootstocks was secured as early as the third year of planting, while the seedlings of the same variety failed to reach bearing stage for eight years after planting. With the acid limes also, the difference in yields between the seedlings and the budded trees on one rootstock in an experimental plot was so great as to amount to a ratio of 1 : 4 in the sixth year of planting. With lemons the first crop in several varieties propagated by budding was secured in the second year of planting in such diverse situations as those in Rayalaseema and the West Coast, while the lemon seedlings at Kodur fruited for the first time only in their eighth year.

The inherent susceptibility of each species of *Citrus* to certain diseases has been circumvented in many parts of the world by employing rootstocks inherently resistant to that disease. The power to withstand wind damage is also likely to be increased through rootstock influence. These provide ample justification for any drive towards the popularisation of vegetatively propagated citrus trees in future plantations.

RAISING ROOTSTOCKS

Although several vegetative methods of citrus propagation are known and practised, none has proved so convenient and useful in large scale nursery practice and for orchard performance respectively as the method of shield budding. This involves the raising of seedlings of desirable rootstocks for the purpose of budding. The seeds of the variety to be used as rootstock are extracted by squeezing the fruits. They are then washed free of pulp, dried off in shade slightly, and sown soon after on raised seed beds, which are roughly four feet long and two to three feet wide and about six inches high, with a spacing of about an inch in the row and three inches between the rows. If more than one seed bed is necessary, they are all made alike with about six to seven inches of space separating the beds to form straight channels or furrows criss-cross and at right angles to each other. If some delay in sowing the seeds is inevitable, they should be packed in powdered charcoal in tins or boxes with a close fitting lid on. From large scale observations it has been found that the number of seeds per fruit ranges from six to ten with rough lemon, 20 to 25 with Sathgudi, 40 to 45 with Gajanimma, 20 to 25 with Kichili, 10 to 15 with loose skinned orange and eight to twelve with acid lime. A thin layer of sand may be thrown over the seed beds to prevent dislodging of the seeds during watering. Soon after sowing as well as in about the first two months, watering of the seed beds is done carefully from a low height with cans each fitted with a fine rose. When the seedlings have grown about three inches high, flow irrigation through the furrows between the beds is possible, in such a manner as to allow water to reach the surface level of the soil on the beds.

The seeds germinate in about 20 days of sowing. The germination percentage has been found at Kodur to be roughly 50 in Herale (sour orange), 43 to 62 in Sathgudi orange, 62 in Gajanimma, 85 in Billi Kichili, 80 in acid lime, 99 in rough lemon and

91 in pummeloes. In addition to these, a large number of nucellar seedlings also arise, amounting roughly to 2 per cent. in Herale, 4 per cent. in Sathgudi, 16 per cent. in Billi Kichili, 39 per cent. in acid lime, 57 per cent. in Kichili, 65 per cent. in Gajanimma, and 73 per cent. in rough lemon. Pummelo failed to produce a single nucellar seedling, thus living up to its character as a mono-embryonic fruit. The figures given above also establish that the rough lemon has contributed to the highest germination and the production of the largest number of nucellar seedlings in seed beds at Kodur.

Six to nine months after sowing, the seedlings are lifted individually with naked roots, commencing the operation from one end of the bed and preserving as much of the root fibre as possible, and transplanted into flat nursery beds after roguing out the weak, unhealthy and undersized ones. The beds are flat and may be of any convenient size, but generally not exceeding about 40 feet in length and 20 feet in width. The soil has necessarily to be well worked for enabling the digging of pits with a hand tool or more advantageously and economically with a nursery transplanter. The lifted seedlings are generally transplanted with a spacing of 9 to 12 inches in the row and 18 to 24 inches between the rows; and are irrigated immediately afterwards. There is a conception that if the most vigorous seedlings only are selected for transplanting and for subsequent budding, such budded trees will continue to be more efficient performers than those budded on less vigorous seedlings. This was found to be inapplicable to Sathgudi budded trees, when the rootstock seedlings were raised after roguing out of only the unhealthy and markedly undersized seedlings. If the roguing out is done at the time of transplanting to eliminate those that are not likely to become buddable in about 24 months of sowing, it seems all that is necessary for securing good trees.

Records taken in November 1936 with seedlings sown in beds in December 1935 and transplanted to beds in about August 1936, showed that the percentage of seedlings that attained the buddable stage during the period of about 11 months varied greatly between various species of *Citrus*, the actual percentage of plants of buddable size (those with a stem diameter of 0.70 cm. or over at 9" height from the ground level) being two in Sathgudi orange, three in acid lime, six in Kichili, twelve in pummelo, 53 in rough lemon and 59 in Gajanimma. The mean height of seedlings also varied considerably ranging from about 38 cm. in Sathgudi to 62 cm. in rough lemon. Billi Kichili failed to produce a single seedling of buddable size in this period. By choosing more fertile soils and by frequent stimulation to growth with application of fertilizers or manures during the rainy season two to three months either before or after transplanting, it may be possible to secure a better growth and a larger number of plants of buddable size.

Apart from irrigations at the required intervals as determined by seasonal influences (roughly a 8-day interval having been found adequate at Kodur in light loamy soil in hot and dry periods), almost daily hand picking of citrus butterfly caterpillars will be necessary both in seed and nursery beds. An occasional removal of side shoots in nursery beds, roughly once every three months, is also useful to encourage a straight and smooth stem, which is of importance to facility and success in the subsequent budding operation.

BUDDING

In 18 to 24 months, depending upon the variety and care given, almost all the seedlings in nursery beds will be ready for bud insertion. The first budding is commenced in about 12 months with a rootstock like the rough lemon, while with the slow growing Billi Kichili it may be possible to do so only after 18 months of sowing. A few days before bud-insertion, the removal of side shoots should be done carefully. The bud stick should be from round or cylindrical wood dotted with gray streaks on a green background and containing thornless but plump, axillary buds. They should be selected with care from productive, high quality and healthy trees. Such a tree selection has proved its value in securing a high degree of uniformity in yields within a clone. The policy of taking buds uniformly from high-yielding trees that show no tendency towards instability has also been found to be fundamentally sound and applicable to *Citrus*. In view of the immense variations in yield among the trees of Sathgudi orange shown in another place, the value of tree selection becomes specially important for transmitting high yields to the progenies in future plantations.

From a trial conducted in 1936-1937 at Kodur on the budding of Sathgudi orange on Gajanimma and Kichili rootstocks it was found that the optimum months for bud insertion were July and September. During the remaining months, high " take " of buds was obtained during January, February, August and June, while March to May and November proved unfavourable. The latter were the periods which were characterised by prolonged hot and dry spells or heavy precipitations. These show therefore that extremes of wet weather or temperature are both limiting factors in citrus budding. Excessive dry and hot weather from March to June has also been found to injure the young sprouts. This will render February or even January bud insertions also undesirable in many years. Considering all these factors, July to September may be taken as the most favourable period for budding at Kodur. October to January may also be chosen, if the north-east monsoon does not cause heavy precipitations during the budding period.

The bud is inserted on the seedling stem at a height of 9 to 12 inches from the ground. T or inverted T method can be adopted depending upon the operator's convenience. After the insertion of the bud, wax cloth strips or raffia fibre are used as bandaging material around the bud. A method of preparing waxed cloth is to dip rolls of cloth strips, each 8 to 15 inches long and one-fourth to three-eighth inch wide, in melted paraffin.

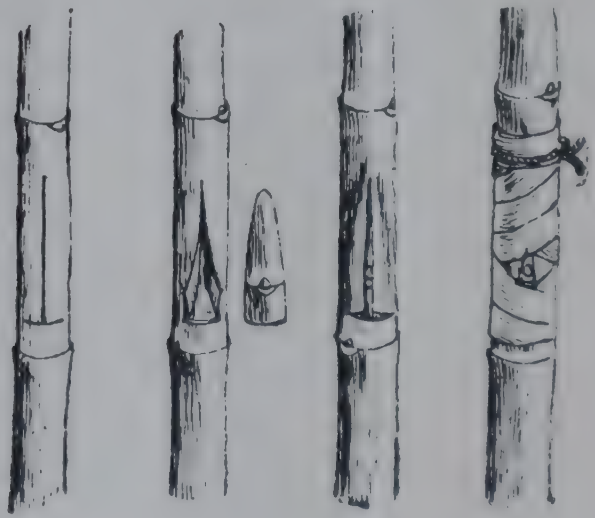

Fig. 53. Shield budding of the citrus

Extensive trials have proved that under Kodur conditions, the insertion of bud shield with a very thin slice of wood not exceeding 2.50 cm. x 0.40 cm. x 0.15 cm. attached to it, is desirable. The size of the wood should be the same as was obtained by the operator at the time of slicing out from the bud stick. He should be prevented from inserting any bud shield which was not found to the mark or in which case the size of the wood had to be reduced after the slicing out. In other words, the operator has to be sufficiently trained in order to be able to skilfully slice out the bud shield of the required kind. When a rough and un-uniform slice of wood is retained in the bud shield or when the horizontal cut is too large or when the bud shield is ill-fitting, a callus pad of large size results, which serves to raise out the bud shield causing a swollen bud-joint. The presence of a thin piece of wood has contributed to over 32 per cent. higher " take " of buds on Kichili rootstock. The slice of wood also does not seem to have any material influence on the extension growth of the bud sprouts, which grow normally whether the slice of wood is present or absent. The removal of wood from the bud shield may also involve some risk of injury to the bud shield.

The common practice of the budders to retain the bud shield in water or inside the mouth of the operator in contact with saliva is likely to hinder the successful " take " of such buds. It is suggested that the bud shields after removal, should be inserted quickly with the minimum of exposure and without contact with any kind of liquid. A metal case with sphagnum moss lining is found to be a suitable container for bud sticks, from which the bud sticks can be taken out when required.

It is common for some nurserymen to lop off the rootstock stem above the bud-joint as soon as the bud insertion is done and the bandaging is completed, while others do this operation in about five to six weeks afterwards or when the bud prouts have put forth two to six inches of new growth. From the trials at Kodur, it is seen that the latter delayed lopping is preferable, since it would be in consonance with the plant requirements. Lopping at the bud insertion stage did not actually affect the " bud-take " at Kodur, but stimulated an earlier " bud-break " by about five days with Sathgudi orange on Kichili rootstock. With acid lime scions, lopping at the time of bud insertion, however, lowered the " take " by about 20 per cent. on Kichili, and the "bud-break" was earlier by about 20 days. As against these, the delayed lopping of 1ootstocks after the inserted buds have produced not less than two inches of extension growth, has resulted in a comparatively rapid extension growth of bud sprouts. For producing a larger number of budded citrus plants and for encouraging an early maturation of bud-sprouts, insertion of bud shield with a thin piece of wood attached to it and primarily lopping of the rootstocks after the bud-sprouts have produced not less than two inches of extension growth, are found under Kodur conditions to be, therefore, the most suitable practices. The final lopping of the rootstock stem may be done prior to the sale of trees or at the time of planting the budded trees in the orchard.

On the basis of a study of the "take" on various rootstocks and of their root systems and performances in the nursery stage at Kodur it has been gathered that, rough lemon is the most suitable. It has produced the highest germination, largest number of nucellar seedlings, a very high proportion of vigorous variants ready for budding within about a year from sowing, and a very high "take" of Sathgudi orange and acid lime buds. Rough lemon seedlings also transplant well and make a good stand in nursery beds. Their root system in the early stages is well distributed, possessing an abundant fibre and good depth. The scions also grow vigorously during the pre-orchard life. Gajanimma, though has shown to be the most vigorous rootstock, suffers from such defects as poor germination, high variability and a high susceptibility to gummosis. Pummelo, being mono-embryonic, cannot possibly appeal to the nurserymen and orchardists. It has further produced varying percentage of "take" with different scions. The varying "takes" of buds, on Billi Kichili, its poor transplanting and the low proportion of vigorous seedling variants in the first 12 months of sowing are the defects which may rule out this rootstock from commercial nursery establishments. Sathgudi orange is very slow in growth both before and after being used for budding, besides producing a poor germination and low production of nucellar seedlings. Its relatively higher weight of root to top growth, easy transplantation and well balanced root system are, however, points that require to be considered in its favour. Kichili has shown a poor "take" with acid lime scion and has also not produced a very high germination of seeds or high uniformity in seedlings. It has also sparse fibre in the root system in early stages. But for these defects and possibly its relatively slow growth in the beginning, this can well be classed among those to be fancied by the citrus nursery trade. The sour orange has germinated poorly and produced low percentage of nucellar seedlings. Acid lime was found not easy to transplant, at least not as well as the rough lemon, nor as efficient in producing vigour in the budlings in the nursery beds. In other respects it possesses most of the favourable characters of a good rootstock. The above features cannot possibly furnish any clue to the future orchard performance of these species and varieties when used as rootstocks, although they are likely to be of value to the nurserymen and to the growers in understanding the peculiarities of each in the nursery stage.

During the period from bud insertion to the lifting of the budded trees, regular hand-picking of citrus butterfly caterpillars and removal of rootstock sprouts should be done. Suppression of weeds in the nursery beds either by hand-hoeing or by working Planet Junior Hand Hoes, is also necessary. Tender and sappy growth will be fostered if the beds are heavily or frequently manured or fertilized. This is not desirable, as such plants stand transport or transplanting poorly. Regular irrigations during dry and warm periods are necessary as in the case of seed beds, and this is rarely done at less than eight-day intervals even in the hottest period in loamy soils at Kodur. Staking of the budded trees to induce a straight stem is regularly done in some countries, but this is never done in South India. The budded trees are generally sold or planted out in orchards in 6 to 12 months of bud insertion. The lifting of trees is always done with a ball of earth in cases of budded plants and even in seedlings, excepting in heavy rainfall tracts as Coorg and Wynad, where lifting of seedlings with naked roots does not seem injurious to the life of trees intended for planting in a day or two of lifting. Plants lifted either with balls of earth or with naked roots are packed with a gunny or straw covering before transplanting them outside the nursery.

Other propagation methods :—Spontaneously produced layers (or suckers) from low hanging shoots is common with some *Citrus*. Lemons of several varieties like Nepali Oblong and Round have particularly proved fruitful sources of such plant material, the mean production from eight-year old trees having been 48 per tree in these two varieties with a maximum of 103 layers from one Nepali Oblong tree in that year. Layering especially with limes and citrons and inarching with sweet oranges and loose skinned oranges have been fairly popular in South Indian nurseries before the art of budding became popular. These are being practised even at present by nurserymen who are not well conversant with budding. To meet the large demand for seedlings, many nurseries also raise even now the Sathgudi orange, acid lime and pummelo by seed, but in very few cases are the seeds in these cases sown on raised beds. They are generally sown direct in flat nursery beds, where they are allowed to stand for three to five years when they are lifted and sold out. Propagation by cuttings is also practised to a very small extent with citrons and sweet limes.

BUD AND TREE SELECTIONS

Indiscriminate selection of buds from scion trees is more a rule than an exception in this country. A careful inspection of any orchard will show that trees differ in yielding capacities, health and fruit quality to a great extent between themselves. Sometimes such differences are noticed between parts of even the same tree. These variations may be found both in seed propagated and budded orchards. Selection of buds from trees regardless of these variations may lead to a progeny of low performance, and has therefore to be deprecated.

The scope and value of selection of trees as sources of buds or scion material has been a subject on which there is no unanimity of opinion. In the case of all observed variations of yield and for the purpose of tree selection it is essential to prove that the variations are inherent, as distinct from the influences of soil, climate, rootstocks, culture, pests or diseases. In seedling citrus plantations, some trees may arise as chance seedlings due to promiscuous crossing in the preceding generation. The difficulty of distinguishing the variations caused by such fortuitous factors from those due strictly to genetic factors is great. However, work at Kodur has shown that selection of mother or scion trees is very necessary in acid lime, as it leads to a high degree of uniformity in yields within both the vegetative and seedling progenies of such selected parents. The policy of taking buds uniformly from high yielding trees of superior quality and that show no tendency towards instability may also hold true with other *Citrus* as well.

Tree selection has often been confused with the bud selection methods conceived and developed in the United States of America and some other countries with notable results. In *Citrus* and in some other fruits, variations from the original or parental type are often found on parts of the same tree. Such variations may be confined to a single bud or an entire branch. Such variant parts may reproduce similar progeny when assexually multiplied or they may not. In the former case, the variant limb or bud will be designated as bud sport or bud mutation, and in the latter case as bud variation. In actual practice, the term bud selection implies the selection of buds for propagation from inherently stable and superior fruiting parent trees. It is distinct from bud variation, which is used to designate new bud forms before they have proved to be heritable as true bud mutations or bud sports. Thus, whenever a variant tree or part of a tree is observed, it is necessary to prove whether the variations are inherent or not by vegetative progeny tests.

Bud variations are very frequent in some *Citrus.* One of these noted on a branch of a Vadlapudi orange tree at Tenali was found to produce fruits distinct in some fruit characters from that of the rest of the tree. Progeny tests with the buds of the variant branch showed at Kodur that the variant characters could be reproduced asexually. Thus, a new vegetative or bud strain of Vadlapudi orange was secured, and this has been referred to already in the above pages. Many outstanding new strains have been produced in a like manner in other countries, particularly in the United States of America.

Bud selection is also necessary to reduce the proportion of off-type trees in orchards, that get themselves introduced due to careless selection of buds. Since bud variations may be both of desirable and of undesirable types, the latter being more frequent than the former, a careless selection of buds may unintentionally lead to the reproduction of inherently inferior mutations. Every nurseryman should therefore pay careful attention not only to select the best mother trees, but also to draw buds from only such parts of the selected tree that are found to conform to the standard type, form or variety.

ROOTSTOCKS

Experience of growers all over the world has proved that rootstock influence is one of the most determining factors in citrus orchard economics. Growth of trees, pest and disease incidence, yield and quality of fruits, adaptability to soil and environmental conditions are only some of the directions in which rootstock influences exert to shape the orchard income. It is only during the last decade that budded citrus plantations began to appeal to the fancy of the South Indian public. Research on citrus production including the field of rootstock influences were initiated only after the Fruit Research Station was established at Kodur towards the close of 1935. There is, therefore, neither any accumulated experience of the growers nor the results of any completed scheme of research available to guide the public. To meet the growing demand for information on the subject at the present stage of transition from the seedling to budded plantations, an elaborate rootstock trial with Sathgudi orange scion and a smaller one with acid lime scion have been under way since about 1936. From the very nature of these experiments, it is impossible to expect definite results with any degree of finality within a short period of time. With a crop like *Citrus*, a very conservative estimate of the period necessary to determine with some exactitude the longevity of scions on various rootstocks would be not less than 50 years. Pending the availability of results from such long range experiments, it is only possible to furnish interim results or observations with an idea of the rootstock influences as gathered from the recorded experiences of workers in other parts of the world.

It is well known that any *Citrus* species or variety can be budded on any other species or variety of *Citrus*, but the tree performances can never be exactly alike on any two rootstocks, nor can the performances of a scion variety on a given rootstock be similar in all climates and soils. For sweet orange, California prefers the sour orange, Japan the *Citrus sunki,* parts of Florida the sweet orange, Palestine the sweet lime or lemon, the Nile Valley the acid lime, and some colder parts of the world *Poncirus trifoliata.* In many countries rough lemon is chosen for light soils and the sour oranges for heavy soils. In this country, the rough lemon has been the most popular rootstock so far for sweet oranges, but for the loose skinned oranges the sweet lime has been found equally or more suitable in some places. Experience in other countries points out to the fact that sour orange rootstock produces fine quality sweet orange fruits in heavy soils at an early age and can suit the mandarins also, but it is not adaptable to light soils. It is also reported to stand waterlogging better than the rough lemon. The sweet orange is said to be susceptible to foot-rot, besides being slow to reach bearing. Trees budded on this stock do not also thrive well on light soils and do not withstand drought conditions. These few instances suffice to emphasise the importance of rootstock trials in every citrus producing country.

The Kodur trials up-to-date have given the following indications:—

1. Sathgudi trees budded on acid lime, gajanimma and rough lemon are most vigorous in growth, having produced the largest tree size in about nine years, while those on wood apple and loose skinned orange were the poorest in size.

2. Smooth bud union, which is a sign of compatibility, was found in maximum number of Sathgudi trees budded on Sathgudi, while disparity was greatest on wood apple and kichili, with the trees on sour orange and pummelo being intermediate.

3. Sathgudi trees on wood apple and gajanimma yielded crop the earliest, while the seedling trees are yet to reach the bearing stage.

4. Trees on gajanimma are the most susceptible to gummosis and root rot diseases, the latter only in years of heavy rainfall.

5. With acid lime scion no appreciable differences in tree growth has occurred between rootstocks, though trees on rough lemon show the largest stem size, and the budded trees have clearly recorded larger tree size than the seedlings.

6. Smooth bud unions are associated with acid lime on acid lime, while the former on gajanimma has displayed the largest extent of uncongeniality.

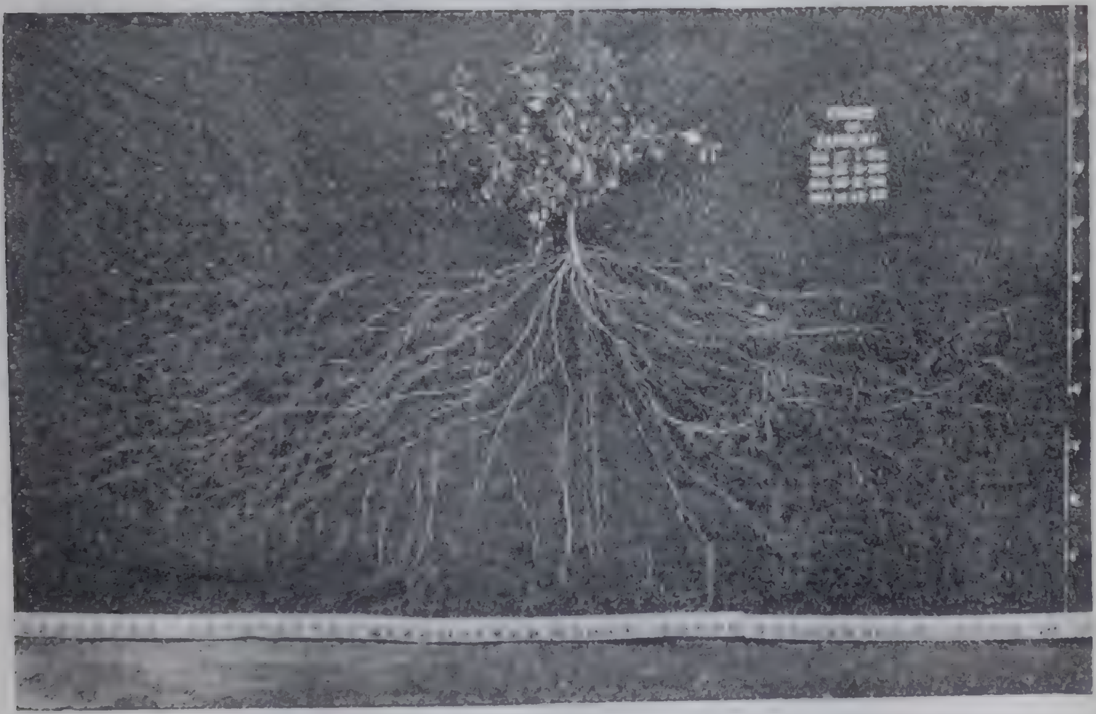

Fig. 54. Root system of a young Sathgudi orange tree on rough lemon rootstock.

7. The budded acid lime trees have been clearly more precocious than the seedlings by about a year.

8. Acid lime trees on gajanimma, acid lime and rough lemon appear in the order given here in respect of heavy yielding capacities, with acid lime seedlings in the bottom rank.

9. Acid lime seedlings and budded trees on the same rootstock are the least affected by die-back or wither-tip diseases, with the trees on gajanimma showing the largest amount of dead wood as a result of the incidence of these diseases.

On an acreage basis it has been worked out that, till the eighth year of planting the acid lime budded trees on gajanimma have yielded at Kodur 4,37,945 fruits weighing 42,036 lbs., those on rough lemon 3,14,600 fruits weighing 28,545 lbs., those on acid lime 3,79,242 fruits weighing 33,812 lbs., while the lime seedlings yielded in the same period only 2,49,976 fruits weighing 21,988 lbs. Each of these treatments had 18 trees. It will be generally conceded that, regardless of the possible variations in ranking of the treatments that may result with the further ageing of the trees, the foregoing differences are so large as to induce the acid lime growers to go in for budded plantations

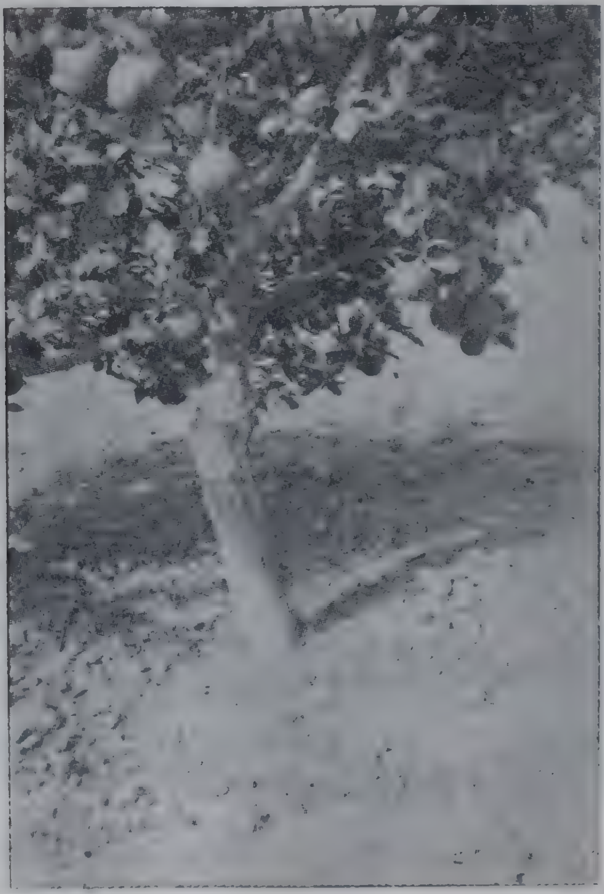

Fig. 55. Sathgudi on wood apple rootstock
with incompatible union.

in preference to those of seedlings, and particularly to plantations on gajanimma rootstocks.

It is unfortunately not possible to present similar results from Sathgudi orange rootstock trials, since these trials were vitiated by root rot incidence to an extent as to make the results unreliable. However, it seems clear that wood apple (*Feronia elephantum*) is a very dwarfing and incompatible rootstock for Sathgudi, though yielding crop at an exceptionally early age with fruits of excellent quality. It is likely from its present appearance that this rootstock will reduce the tree longevity considerably, as to render the use of it unprofitable in commercial plantings. Till more definite results are available, rough lemon may be recommended as a suitable rootstock for the Sathgudi at least in light soils, while the sweet orange and acid lime may have also value, the former because of its ability to give good quality fruits from the very commencement of bearing, and the latter because of its reputed resistance to water logged conditions.

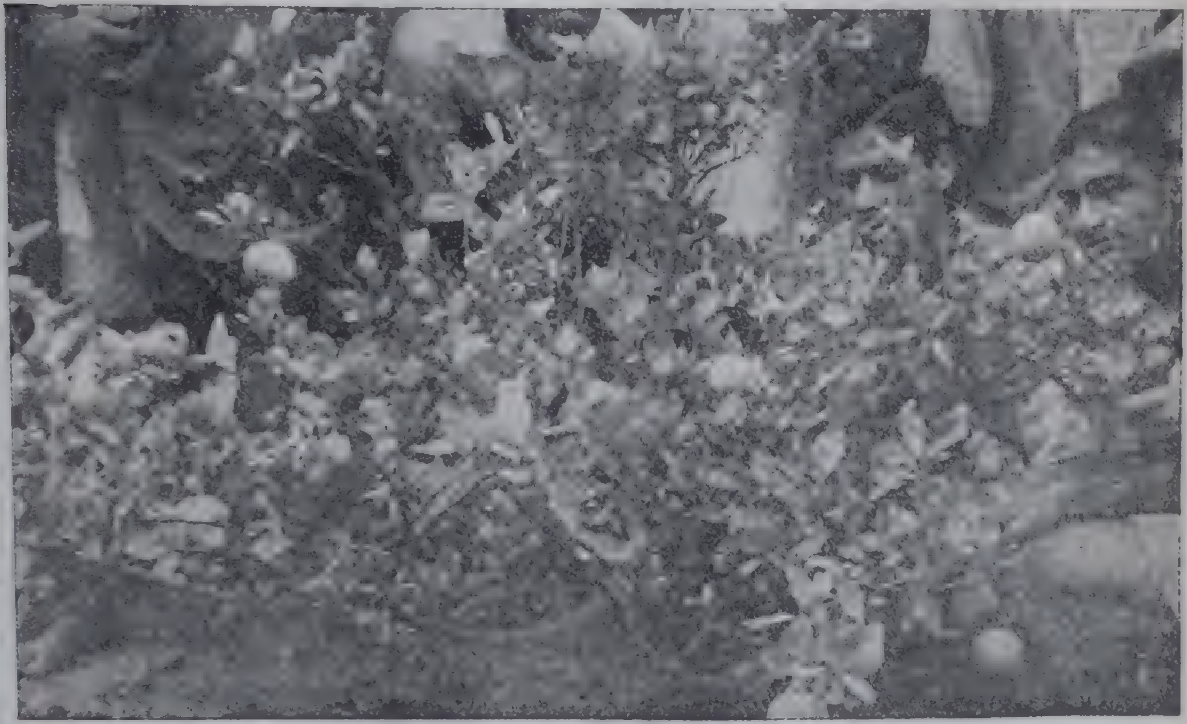

Fig. 56. Precocious bearing in Sathgudi orange on wood apple rootstock.
(Courtesy of Sri C. Rajasekara Mudaliyar.)

It has been reported by an experienced and enterprising grower from the West Coast that in his sandy soils the lemon suckers have started better than the budded trees on rough lemon rootstock, producing also crop a little earlier. By the second year of planting, about 75 per cent. of both batches of lemon trees were in bearing, a feature not attainable with seedlings. In point of yield, there was no difference between the layered trees and those budded on rough lemon. The same grower reports that lemon gooties flowered in the very first year of planting.

SPACING

In Sathgudi orange seedling plantations, 27 to 30 feet spacing is the general rule. For budded trees, 22 to 25 feet seems adequate in normal soils on rough lemon, sweet orange and acid lime or similar vigorous rootstocks. Acid lime seedlings have often been planted with 8 to 12 feet spacing on poor and open soils, but on rich and close textured soils as those in Kistna deltas near Bezwada, a 25 to 30-feet spacing seems more suited to the needs of this fruit. Even in a loamy soil at Kodur, it was found that by the eighth year of planting acid lime seedling trees with their more erect habit of growth than the budded trees, covered a space of 17 feet in diameter, while the budded trees showed a significantly larger spread. These trees are yet to reach their prime bearing age. Any spacing of less than 20 feet to acid lime is therefore manifestly inadequate even in light soils. Budded lemon trees also grow to as large a size as the sweet oranges, and so do the pummeloes. For Vadlapudi orange in rich soils of Kistna and Guntur as much as 36 feet spacing is often given, while the Batavian orange seedlings on such soils are grown with a spacing up to 3 feet. The kumquat is the least spreading, while the grapefruits o the higher elevations at Coonoor on certain rootstocks were als

Fig. 57. A newly planted sweet orange plantation.

found to spread little as to require a spacing of not more than about 18 feet. But on the plains they too may become crowded with a spacing of less than 20 feet. The loose skinned oranges when grown as seedlings on good soils seem to prefer a spacing of 22 to 25 feet like the Sathgudi. In all citrus, the spacing to be given will depend on the expanse of top of adult trees, even though the roots do extend far beyond the top spread. Root studies at Kodur in 1946 have revealed that the root zone varies to a very great extent between soils. In two Sathgudi orchards of 9 to 10 years of age planted roughly with a spacing of 27 feet, it was found that the feeding roots had fully covered the entire alley space in a red, medium loamy soil of uniform texture up to about six feet depth, while in lighter loams of lower fertility status and of a higher alkaline reaction, no feeding root was met with in the centre of the alley. The studies also revealed that in the soil profiles, 41.6 per cent. of the feeding roots occurred in the former grove in the first foot layer at the centre of the alley, 24.4 per cent. in the second foot layer, 19.4 per cent. in the third foot layer, 11.7 per cent. in the fourth foot layer, and 2.9 per cent. in the fifth foot layer. No feeding roots were found below this level in the centre of the alley. These facts establish the need for different spacing in soils of varying texture, consistency, chemical composition and fertility on one hand, and the fact that over 85 per cent. of the feeding roots occur in the first three-foot layer of soil and over 65.0 per cent. in the first two-foot layer. They also show that root spread is far beyond the branch spread, since in the first of the groves mentioned above, the maximum tree spread on any two sides of the tree stem was not above 19.4 feet, while the root spread had extended to beyond 27 feet.

Planting—As with the mango, pits of 2' x 2' x 2' seem adequate for citrus trees, and these may be dug beforehand and refilled with the dug-out soil a few days before planting. At the time of planting only a small amount of soil in the centre of the covered pit needs to be taken out for accommodating the ball of earth around the root. The soil around the ball of earth should be firmly pressed down without injury to the ball of earth; and after the surface is levelled and a basin formed, water should be applied immediately. Citrus trees also are best planted in the afternoons rather than in the mornings or during the mid-day. Slight wetting of the upper surface is a practice to be avoided, as well as excess of water that may lead to prolonged water stagnation. A dry, hot and windy season is unsuitable for planting. Normally July to December provides the most suitable period in most parts of South India. A plant just commencing to produce new shoots or in which the new shoots have been formed only a short time before planting and therefore still in a growing condition, is not fit for planting. Only those plants in which growth has ceased for the time being and shoots have become mature with a total absence of tender leaves or shoots on them, should be selected for planting. The bandage around the bud-joint should be carefully removed before or immediately after planting. The plant should be set at the same depth in the orchard as it was in the nursery. To prevent damage by wind it is also advisable to raise a quick growing hedge, if the regular wind break belt is not established previously or is still not functioning well because of young age of the trees in the belt.

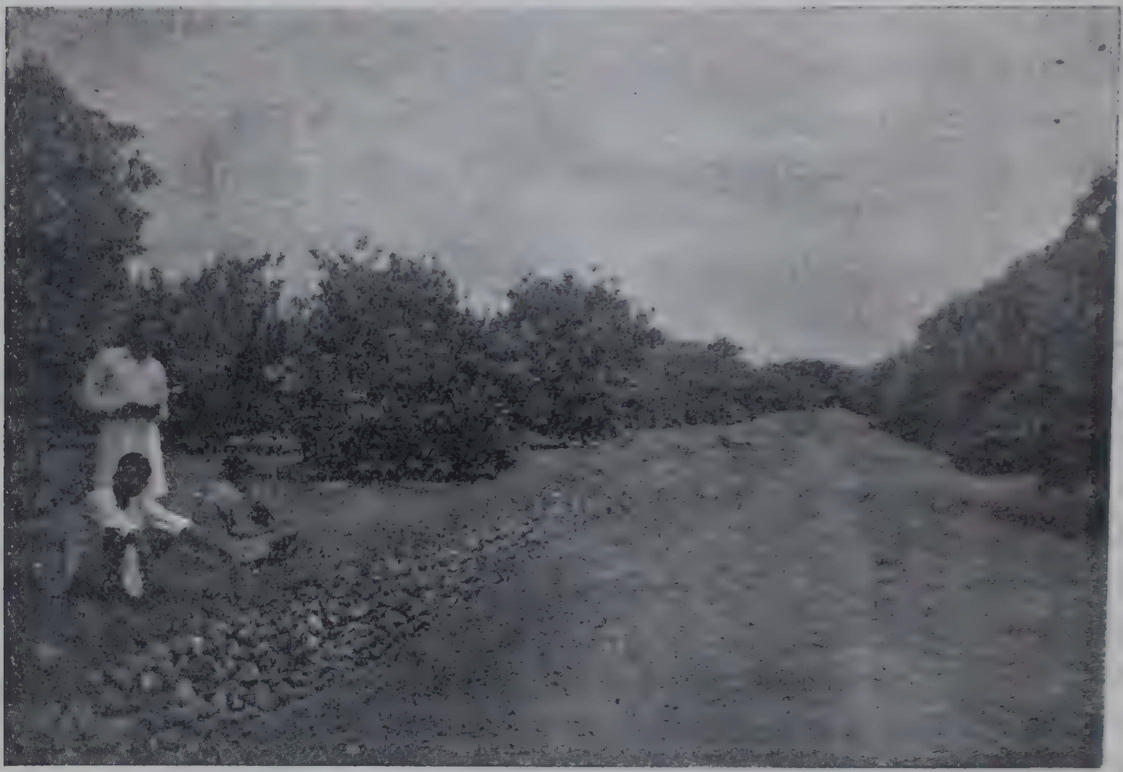

Fig. 58. Central road with an open drain in an orchard.

IRRIGATION

Except under rain-fed citrus producing areas as those found in Coorg, Wynad, Yercaud and similar tracts, citrus trees require artificial irrigation at frequent intervals. Irrigation is the largest item of expenditure in many parts, amounting roughly to one-third to one-fourth of the total maintenance cost of the orchard in any one year during the bearing age. The almost universal method of irrigating young citrus groves is by the basin method. Water is led in channels to tree basins which vary in size according to the age of the trees and are about three to six inches lower than the ground level. In general, the basins used in private citrus orchards are too small to meet the needs of the trees. Root studies at Kodur have proved that tree spread is not a reliable index of the feeding area of the roots, which though depending on the rootstock variety, nevertheless covers a very much larger orchard space than that actually encompassed by top growth. The enormous foraging power of roots of certain varieties is evidenced by the maximum spread of 543.0 cms. on a Sathgudi orange on gajanimma rootstock after about 21½ months of bud insertion. Other workers have also adduced evidence to show that the roots of citrus trees extend often two to three times the spread of branches. The wide-spread practice of applying water as well as manure in small basins within the drip of leaves is therefore obviously inadequate. In young trees the basin should extend two to five feet beyond the branch spread. A gentle slope may be provided inside such basins to permit a six inch water depth at the periphery of the basin during irrigation, as has been explained under mangoes. The widening of the basin must be done every year. The weeding around the tree trunks is considerably facilitated and economised by the use of Planet Junior Hand Hoes, which cannot be used in basins restricted to within the drip of leaves. Water inside the basin is not allowed to stand in prolonged contact with the tree trunk by the provision of a gentle slope inside the basin, and the moisture becomes available to almost the entire root zone. It is not advisable to heap up a large amount of soil round the tree trunk; only that much of soil that will serve to raise the space immediately round the stem by about six inches from the level of the basin towards the periphery should suffice. To achieve the purpose of keeping off the water from prolonged contact with the trunk, some growers prefer to form a ring by raising small bunds with soil about a few inches away from trunk. This does not seem satisfactory, since during heavy rains water that flows down the stem accumulates within the inner ring. With no outlet for it, it remains in contact with the stem thus achieving a result exactly contrary to what was intended.

In trees of full bearing age the roots are expected to cover the entire orchard soil. To provide moisture to this extended root system, water is applied either to the entire area by flooding or in large basins formed by straight bunds running in the centre of the rows at right angles to each other. The former method is possible only in very level ground and where ample water is available. Besides encouraging excess of weed growth it is also wasteful. But it has the advantage over extended basins, in that shallow ploughing or hoeing with bullock power in the alleys is possible, while with basin system working of the soil is only possible with hand-tools or small implements worked by hand as the Planet Junior Hand Hoe. Weed growth is also not markedly less in the soils devoted to basin system. The third method followed in other countries like the United States of America is the furrow method. In this a number of furrows are formed between tree rows roughly at a distance of four to five feet from each other. This system of irrigation is only possible in soils which facilitate slow penetration of moisture. In sandy soils the water moves so rapidly in the soil that little or no lateral movement takes place, and on such soils furrow system does not work. The furrow method has not been tried adequately in this country, and till that is done the extended basin method seems to be the only one that can be advocated. The special defect associated with it, namely the difficulty

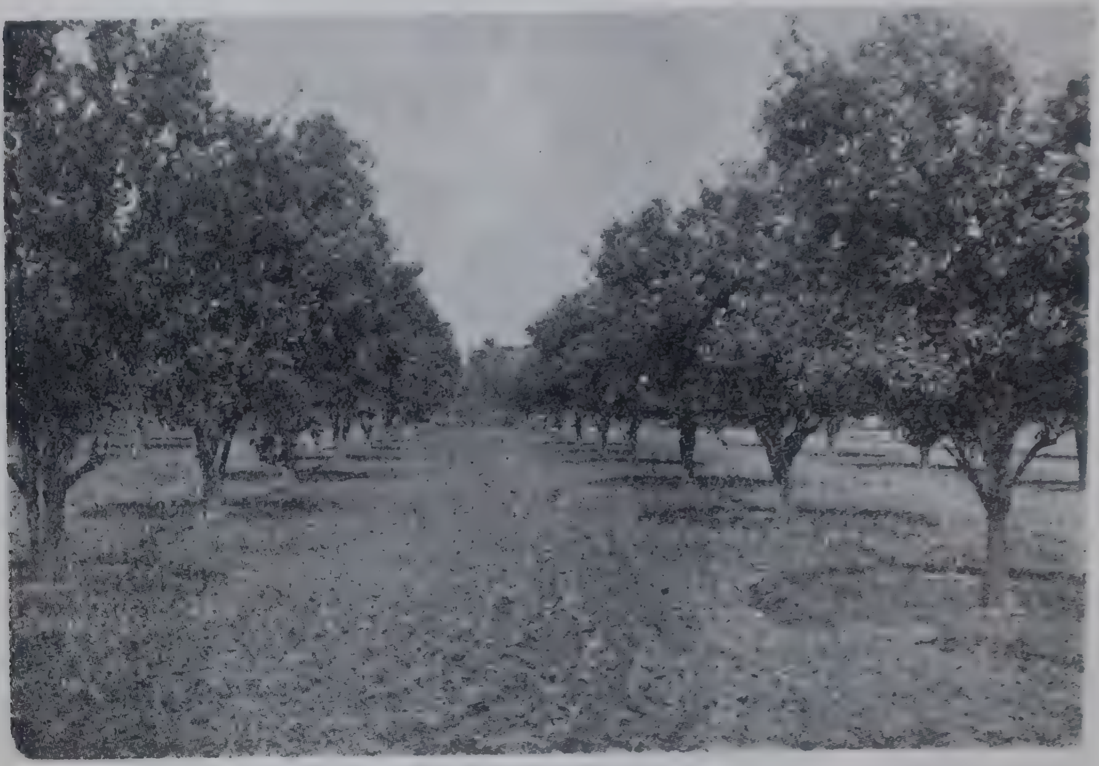

Fig. 59. A seedling Sathgudi grove with small irrigation basins.

of tillage with bullock power, is not a serious one, since frequent deep culture is neither necessary nor desirable, as is shown elsewhere, and much of the weed growth can be kept under check by shallow hoeing with tools like the Planet Junior Hand Hoes.

It must be remembered that excess of water in the citrus orchard soils is as injurious (or perhaps even more so under some conditions) as scarcity of it. Many growers apply water indiscriminately to citrus trees without determining if the trees really need any addition of moisture to the soil. Being in practice, a routine operation done at fixed intervals in the dry periods, it is not uncommon to find some citrus orchard soils continuously in a saturated condition for months, while some others may be very wet and excessively dry alternately. A rough soil test to find out the need for irrigation is to examine the soil up to about 12-inch depth in half-a-dozen spots selected at random from typical parts of the orchard. If the soil is found dry up to this depth of 12 inches, as seen by the crumbling of soil in hand, application of water to the soil will be justified. If on the other hand, the soil is found moist up to 12 inches

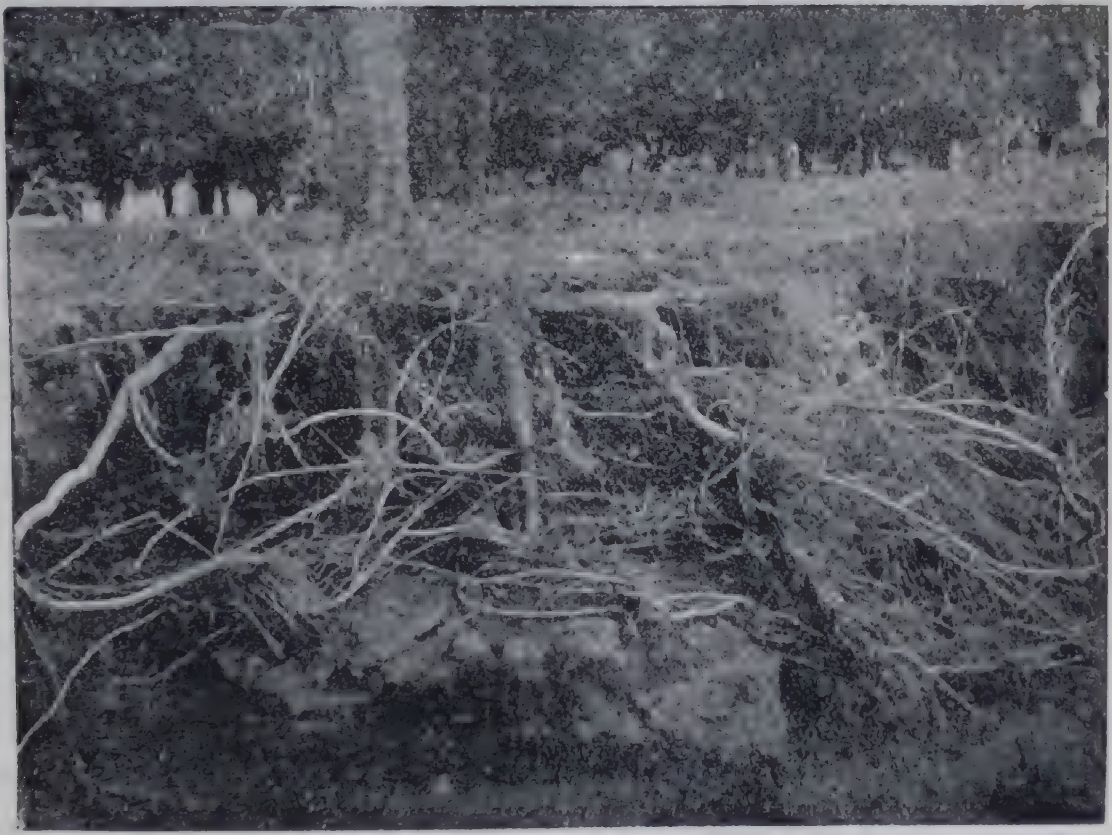

Fig. 60. Well-distributed root frame-work of Sathgudi in a good soil, which prevented the tree from dislodging even when floods corroded the almost entire root zone. (Courtesy of Sri C. K. Anavema Reddy.)

depth, it will be unnecessary and injurious to add more moisture. This rough test is essential, as a superficial look over the surface soil is most often misleading and does not indicate the real requirements of the tree.

The above stated test is helpful in soils of uniform texture but will not hold good in soils underlain with soils of varying texture. Citrus trees penetrate to great depths, as much as a depth of 256.40 cms. having been noted in a budded Sathgudi orange on gajanimma rootstock when the bud sprout was only about 21½ months of age. Even though the root depth is subject to modification by the nature of soil and the type of rootstock employed, it is to be expected that the soil tests have to be made to a much greater depth in soils underlain with stiffer soil layers, since the latter have the tendency to retain moisture for a much longer period than the open soil layers. The selection of uniform textured soils, which has been emphasized previously, is a measure which will not only prevent the need for such deep soil tests, but also promote tree growth and production to a large extent by a more uniform spread of roots, of soil moisture and nutrients.

When intercrops are grown, the tree requirements should be considered as supreme. The selection of intercrops should be done carefully so as not to conflict with the moisture requirements of the fruit. Under a given set of conditions, shallow soils require also more frequent applications of smaller amounts of water than deep soils, just as open or sandy soils, except that in the latter cases the amounts of water with each application have to be larger. Irrespective of the soil and the fruit, irrigation is dependent on the rainfall and its distribution and has to be based on a careful consideration of the soil moisture as influenced by precipitation.

It is advisable to apply water up to four to six inches depth at each application, rather than merely wet the soil surface at irregular intervals, as is done by some growers. It has been pointed out that the water requirements of citrus trees are not the same in all soils, in different seasons and with trees of different varieties, species and ages. Old trees also require more water than young ones; and more frequent applications are necessary during hot and dry periods than during wet or cooler periods of the year. Under certain environments as those in Wynad, no irrigation is given after a year of planting the trees, except in unusually severe hot and dry spells. Because of these various considerations, it is impossible to issue definite recommendations on irrigation practices of all the South Indian *Citrus* as grown under a multiplicity of conditions. The rough soil tests suggested above together with the general hints given in these pages may be useful for practical growers in all the irrigated sections of the region for securing satisfactory growth and yield.

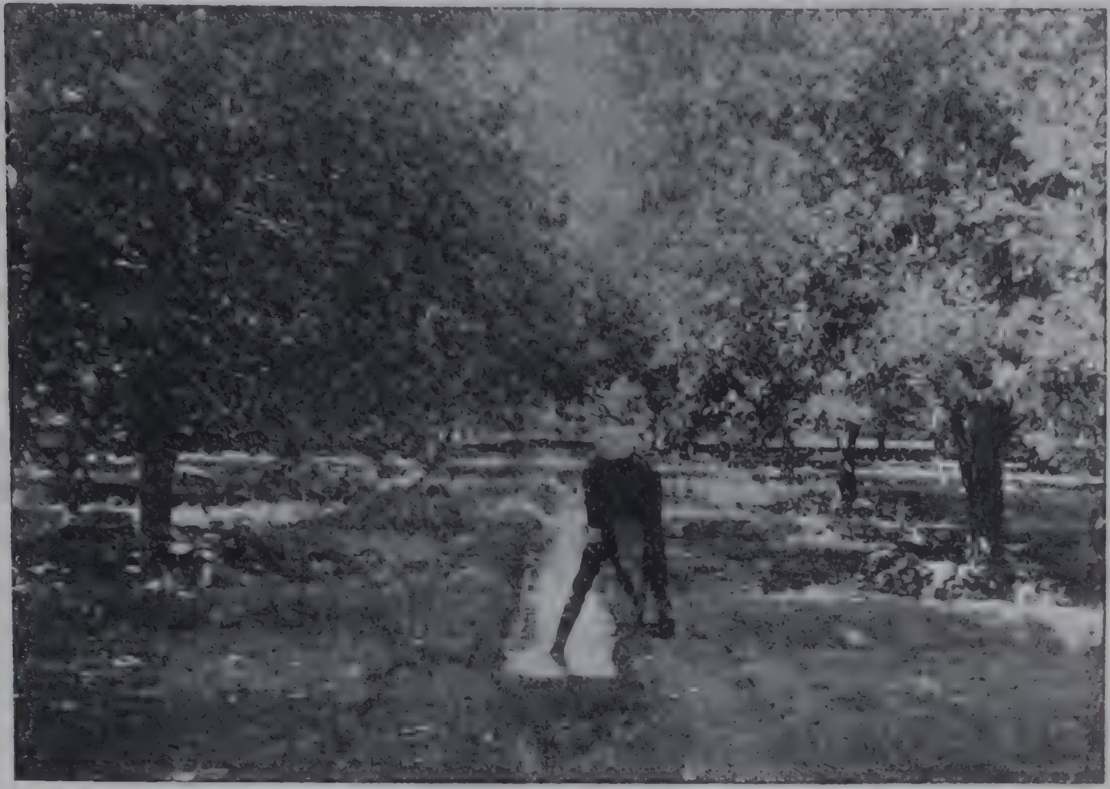

Fig. 61. Basin irrigation in Sathgudi seedling groves.

MANURING

As with irrigation, it is difficult to give definite advice at the present stage of our knowledge on the manurial requirements of citrus grown under the diverse conditions of South India. It is to be expected that different varieties and species will respond differently to a given manure or fertilizer in a particular dosage. Trees of even the same variety may demand different manurial or fertilizer treatments in different soils. The dosage of any manure or fertilizer also varies greatly with the same tree, depending upon its age, health and bearing capacity. It is because of these factors that there is a great divergence in manurial practices in the orchards located even in the same district.

Broadly speaking, a young tree in pre-bearing age requires a higher proportion of nitrogenous manures or fertilizers to foster healthy vegetative growth and a good root system, while bearing trees demand all the important nutrient elements in suitable proportions for securing a proper balance between growth and production.

Intelligent manuring is as necessary for success as any other branch of citrus production. Soil analyses alone are of no great value in determining the manurial programmes of any fruit trees, as they do not show what the trees can absorb or the amounts of nutrients that the soil should possess. Soil texture, rainfall and irrigation practices may also influence the availability and absorption of nutrients considerably as to vitiate the findings of such analyses. For instance in open or porous soils, heavy rains or copious irrigations may leach off soluble salts, making either the soils poorer or sometimes removing the excess of any injurious salts. When the soil is wet, the soil alkalinity is also raised rendering some plant foods unavailable to the trees.

The enormous soil variations even within an orchard as well as the large extent of variability in health, vegetative vigour and bearing capacity of trees, also make it impossible to determine the requirements of trees by simple field trials. For instance, even if a soil is deficient in an element, some trees with larger root systems may be able to absorb sufficient amounts of that element from the larger area foraged by their roots. Similarly, some of the inherently high-yielding trees in an orchard mask the response to a manure application, while inherently sterile or poor yielding trees may fail to show any appreciable response in the same orchard. Clear cut results cannot therefore be expected from straight forward and simple manurial trials.

Trees also suffer not merely from the absence or inadequacy of one or more food elements but also by the reaction of other elements in the soil. Thus, iron and manganese deficiency may be common in soils containing much lime or which are alkaline, while zinc deficiency is also often increased by phosphate concentrations. Ample organic matter in the soil may also change the insoluble phosphates to a form available to the trees and may also act similarly with iron. Boron is known to be more valuable in acid than in alkaline soils, while manganese is said to be very insoluble in neutral or alkaline soils. It is also stated that in slightly alkaline soils (around pH 7), zinc is precipitated and is held out of the soil solution, becoming useless to the plant. All these show hat our manurial problems are highly complex and do not lend hemselves for any rule of thumb advice by either the chemist or he horticultural worker.

For some years past, the sweet orange groves in South India have suffered to varying extents from deficiency diseases. In most cases on the plains, zinc has been found to be the cause for tree distress, while in some orchards the excessive die-back symptoms may partly have been due to copper deficiency. In the more acidic soils as those on the West Coast and parts of the Nilgiris, absence or inadequate availability of other elements are believed to have resulted in serious maladies. In the sandy coastal areas also, evidence has been gathered to show that a number of elements other than those found in the organic manures and common fertilizers are either lacking or inadequate so as to cause poor growth and low yields. The following descriptions of deficiency diseases have been compiled from the American literature with the hope that they will be of guidance to the growers in South India in diagnosing and controlling such diseases.

Nitrogen:—Trees starved of nitrogen as in the neglected orchards, produce yellowish leaves, poor growth and sparse foliage. Some leaves also may drop off. The growth and fruit yields also get reduced. Nitrogen is applied to the soil in nitrate or ammonium form. The former are easily leached off in the soil below the roots. This is why in open and sandy soils about three applications of nitrate nitrogen are advised in a year, usually at the time of formation of new leaves. Even though the trees may use much less nitrogen than contained in the soil, larger amounts have to be applied to provide for loss by leaching and other causes.

Excess of nitrogen is, however, harmful, since trees under such conditions become vegetative at the expense of fruiting. Fruit ripening also gets delayed. In severe cases roots may burn and leaf shedding may occur. Where the soil contains much organic matter and has a poor aeration, excess of nitrogen is very harmful and poisonous.

In normal soils, about two pounds of nitrogen per full-grown tree per year is about the maximum to be applied. Many growers do not apply more than one pound in a year to a tree.

Phosphorous:—When soil is deficient in phosphorous, the leaves develop burned spots, lower leaves being effected first and dropping off. Coarse fruit with thick peel also result.

Phosphorous is usually held lightly in the soil, in upper layers. Ample organic matter in the soil will be helpful in promoting activity of soil organisms which will make the material soluble and available to the plant. If the soil is neutral (around 6 pH), phosphorous is also not leached out, and it is desirable to keep the soil in this condition, if possible. Excess of phosphorous may aggravate zinc deficiency.

Potassium:—Leaves get scorched on one side by deficiency but do not drop off as in calcium deficiency. Shoots also may be twisted and leaves crinkled or cupped.

Farm yard manure contains good amounts of potassium in available form and trees recover rapidly when these or other potash fertilisers are applied.

Excess in the soil may lead to lowered yields and whitish leaf margins.

Calcium:—Deficiency is only in acid soils or in soils of certain areas where heavy rains occur. Leaf tips and margins become yellowish, develop inwards, trees become stunted and shoots may die back.

Lime or other calcium fertiliser application is an efficient remedy. When calcium is in excess the soil becomes alkaline, causing deficiency of iron, zinc, copper and manganese.

Iron:—New leaves are first affected by iron deficiency. They become small and new growth ceases. Some leaves may become almost white, and may fall off. The leaves excepting the midrib, but including the veins, become chlorotic or yellowish in severe cases.

Spraying or injecting iron sulphate to the tree trunk is efficacious, though the effects are temporary. Since the availability of iron is decreased in alkaline soils, acidic fertilizers should be preferred. Excess of watering and phosphates aggravate the iron deficiency, while ample organic matter in the soil will be beneficial.

Magnesium:—Unlike in calcium deficiency, the yellowing of leaves develops from the midrib outwards. Mature leaves become bronzed. The symptoms are more in heavy fruiting trees near the fruit maturing stage.

Regular application of magnesium sulphate is recommended at the rate of two to four per cent of magnesium oxide in the annual fertilizer mixture.

Boron:—Deficiency causes splitting and corking of the midribs and veins of the leaf and also curling downwards. Leaves also may be enlarged and become thick, lustreless and bronzed, and may drop off. Bark of shoots may also split, as in prolonged iron and nitrogen deficiency or excess or deficiency of potassium. Hard, mis-shapen fruits also occur. Gum may form in the fruit, which may be small and less juicy. As against the gums on the outside of the peel and in segments, the boron deficiency gum is inside the peel and in the core.

Boron is more soluble in acid than in alkaline solutions. Excess is poisonous to plant, causing burning of tips and leaf margins, with gum spots on the underside of the leaf, which falls off. Excess of boron is corrected usually by making the soil acidic and leaching it off when soluble. Irrigation water is occasionally the source of boron excess.

Sulphur :—Deficiency causes small leaves and uniform yellowing of leaves, weak bloom in abundance, die-back in weak shoots and small, mis-shapen fruit with thick peel and shrivelled juice sacs and granulated pulp.

When sulphate is added, trees recover quickly. Excess is not common.

Manganese :—Chlorosis of new growth with resinous excrescences result from this deficiency. Young leaves show a network of green veins, though not as distinctly as in iron deficiency. Leaves are not reduced as in zinc deficiency. Fruits do not show any symptoms.

Manganese is insoluble in neutral or alkaline soils and pH may be lowered to about 6 by acid fertilisers.

Excess caused chlorosis in pineapples, but was cured by iron sulphate spraying. This shows how manganese affects iron availability.

Zinc:—Deficiency of this is perhaps the most widespread in South Indian citrus, causing typical yellowing of leaf, excepting of the veins and midribs. Multiple buds are formed, and yields and fruit quality are lowered. Young shoots may die-back. Multiple shoots and die-back are also caused by copper deficiency.

Control is effected by spraying with zince sulphate-lime mixture (5:5:50) regularly. As zinc is almost all precipitated and held out of solution at pH 7, a pH of 6 or lower is the best to maintain.

Excess causes symptoms similar to iron deficiency but is uncommon.

Copper :—Deficiency causes die-back. Large dark green leaves on soft, long, angular shoots are formed and these bend downwards. Terminal leaves are irregular in shape. Gum pockets may appear on the twigs and fruit. Fruits may be one-sided or irregular in shape, and often split. They may also be of poor quality, dry centred and with spotted peel.

Bordeaux mixture spray contains copper and is curative. Application of copper in alkaline soils is useless as it is largely unavailable. Excess is rare, except perhaps in highly acid soils.

Since no set rules are possible to guide every grower of each variety and species of *Citrus*, the advice that can be given to the grower at the present stage is the one that is commonly given in some other parts of the world viz., each grower should undertake a trial of some of the most important manurial or fertilizer practices in his own orchard and should base his future practices in the light of the experiences gathered from such trials. The trial need not be elaborate ; only a row or two containing 8 to 20 trees under each treatment is ample. But the trial when once initiated, should be carried out without change for at least five years. During this period as well as once prior to the commencement of the trial, the grower should note the actual tree yield with rough observations on tree health and vigour. Within the five-year period, the differences between the treatments will be either sufficiently striking or inappreciable. In either case the grower can confidently plan his future manurial practices with the assurance of the efficiency and economics of the selected treatment. A few of the manurial treatments suggested for such a trial with Sathgudi orange are given below.

1. Application of a mixture containing one part of ammonium sulphate, two parts of muriate of potash and 4 parts of

superphosphate at the rate of ½ lb. for young trees, 1 lb. per plant when 12 to 18 months old, 2 lbs. per plant when 4 years old, and 3 lbs. when 7 to 8 years old. A leguminous cover crop like sunnhemp, cowpea, horsegram, *daincha* or *pillipesara* may be grown in between trees.

2. Growing of any of the above mentioned leguminous crops for ploughing them in during October to December, followed by one application of ammonium sulphate at the rate of about 5 lbs. for a full grown bearing tree.

3. Application of a mixture containing 1 part of sulphate of ammonia, 1 to 4 parts of superphosphate, and 1 part of sulphate of potash, at the rate of about ¾ to 1 lb. for a year-old tree. The quantity is increased till the mixture is in the proportion of 4 to 5 lbs. of sulphate of ammonia, 5 to 10 lbs. of superphosphate and 4 to 5 lbs. of sulphate of potash when the trees are over 10 years old. Thereafter the quantities and proportions of the mixture per tree are kept constant.

4. 20 lbs. of well rotten farm yard manure is applied to a year-old tree with 3 lbs. of ash, 1 lb. of bonemeal and 2 lbs. of some kind of oil cake. This is increased gradually till the oil cake and bonemeal are applied to full grown trees at the rate of 5 lbs. each per tree, farm-yard manure at 100 to 120 lbs. per tree and ash at 10 to 12 lbs. per tree.

5. A mixture consisting of 12 lbs. of groundnut cake, 9 lbs. of fish manure, 3 lbs. of bonemeal and 60 to 75 lbs. of well rotten farm yard manure was at one time being applied to full grown orange trees in some parts of Rajampet Taluk.

6. A mixture containing 4% nitrogen, 6 to 8% phosphoric acid, 6 to 8 % potash, 2 to 3 % water soluble magnesium, 1 % manganese and ½ to 1 % copper. This is a mixture recommended in Florida for light sandy soils with a pH around 6 and deficient in the last three elements. Two pounds of the mixture per application are made at the time of new flush to full grown trees. If zinc deficiency is evident, it may be advisable to spray the trees with zinc sulphate lime mixture, rather than apply the same to the trees in the soil. Calcium may be added in the form of ground lime stone or basic slag, if the soil is very acid.

7. Application of 2,000 lbs. of cattle manure or compost and 34 lbs. of groundnut cake per full grown tree per year.

If the trials are laid out carefully on the basis of the experience gained in previous years in the orchard and on the basis of the observed deficiency symptoms on the trees, they should prove very valuable in denoting the manures or fertilizers or the mixtures which produce the best results at the lowest cost.

In orchards where no deficiency symptoms are noticed and the growers merely desire to maintain good health and bearing, it will be necessary to apply only the three important elements of nitrogen, phosphorous and potash. In some orchards, even the applications of the last two may be found unnecessary, except for these contained in organic manures. Whatever be the fertilizer used, its analysis should be known, so that the maximum of each element is kept within the limit of safety and of economy. More than three pounds of nitrogen for instance, is believed to be rarely necessary in South India for full grown tree per year.

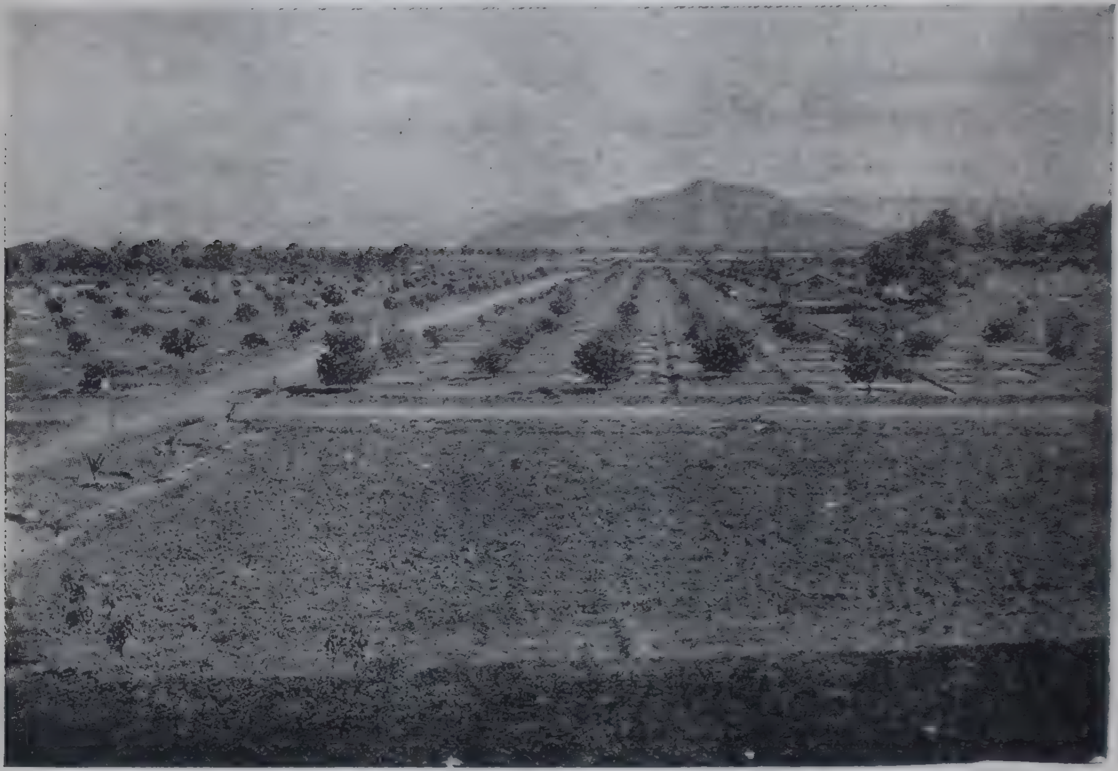

Fig. 62. General view of the citrus variety collection area at the Fruit Research Station, Kodur.

Organic manures like the cattle manures and composts, when well rotted or properly prepared, are found beneficial to citrus trees. Not only they promote soil organism activity and thus make several plant foods available to trees, but may also improve soil texture and soil aeration. Green manuring the orchard soil is also a good way of increasing the organic content of the soil, provided there is ample moisture in the soil for decomposition of the plant material. Application of organic manures and green manuring in dry soils may be injurious.

There is a belief among some Sathgudi orange growers that phosphate manures improve fruit quality and groundnut cake prevents the trees from retaining fruits on them long after full maturity, while cattle manure tends to act differently by prolonging the harvest period. All these beliefs are yet to be corroborated by experimental evidence.

In South India it seems best to apply manures and fertilizers, if it is a single application, in December or early in January, i.e., a little before the blooming period for the main crop on the plains. In the heavy rainfall tracts and on higher elevations, where the off season harvests are completed by June, applications can be done from the end of June to August if soil moisture is available then in the rain-fed groves. December applications in these groves may not always be possible due to lack of soil moisture. In light or sandy soils as well as in soils of low fertility, more than one application per year are desirable, to prevent leaching of plant food in the former cases and to foster good growth or fruit set and development uninterruptedly in the required periods. The dosages suggested above for a year have to be halved if two applications are intended and similarly reduced to one-third in case three applications are intended. More than two applications in a year are rarely done in South India ; and these are timed to synchronise with the emergence of flush or preferably a week or two prior to it. Ordinarily, June to August for an application and December to early January for the second are the periods when manuring is done in South India.

It is common in South India to apply manures and fertilizers by hand in a ring or small basin around the tree. It has already been explained that water and plant food should be applied where feeding roots are found in large concentration. In the case of young trees of pre-bearing age, this should be one to two feet away from the trunk and extending to two to four feet beyond the spread of branches. With full grown trees it would be best to apply from trunk to trunk leaving a space of about one to two feet around the trunks. In all applications, the manures and fertilizers should be well-worked into the soil by ploughing or hoeing, and water should be applied immediately after, unless heavy rains occur within a short time to help the process of decomposition and availability of the plant foods.

The common practice of applying manure or fertilizer to the trees at the time of planting or a little while before or after it, has been shown to be an undesirable practice with mangoes. It is a practice to be deprecated with citrus fruits as well.

INTERCROPS

Besides the raising of leguminous crops such as sunnhemp, cowpea, *daincha,* indigo and *pillipesara* for green manuring the soil, for ploughing-in during a rainy period of the year, for adding nitrogen to the soil, to improve soil texture and keep down the weeds, it is also possible to grow a number of intercrops in citrus plantations in the first few years so as to add to the orchard income. These may be rotated with the leguminous green manure crops. In irrigated groves, where water supply is plentiful and manuring can be done regularly, intensive intercropping is specially desirable during the pre-bearing age of the trees to get the best out of the land. In the choice of intercrops, the growers should be guided by the following points:

1. The intercrop being secondary to fruit trees, should not be such as to demand a differential soil treatment. Thus, growing of paddy which requires frequent and ample irrigation is undesirable as the excess of soil moisture may harm the trees.

2. The intercrops should not be too tall or spreading as to shade the fruit trees. Thus, sugarcane, tall strains of *cholam* or spreading plants like castor are to be deprecated.

3. The intercrops should not be too exacting in moisture and plant food as to adversely affect the fruit trees. Intelligent and intensive intercropping is only possible in rich soil or when ample irrigation and manuring are possible. Subject to the above conditions, the grower has a wide choice open for him. Shallow rooting and short-statured vegetables like beans, carrots, tomatoes, radish, onions, *bhendi,* brinjal etc., are ideal.

In all cases of intercropping, green manuring or cover cropping it is necessary to see that these secondary crops are kept at least four feet away from the tree trunk. Closer than this may lead to shading of trees or creation of conditions to accentuate or foster disease incidence.

Many growers prefer to grow short-stemmed fruit trees in between the taller fruit trees. Pineapple and papayas can thus be grown in citrus plantations, provided these "filler" fruit trees are spaced far away from the main trees and are renewed after the latter reach the fruit bearing stage.

In rain-fed area mixed plantations are often the rule. For instance, coffee is a popular crop planted in between the loose-skinned orange rows in Wynad, Coorg and parts of Mysore. Pineapple is also sometimes planted as fillers in such orange groves. Loose-skinned oranges, citrons and even limes are also occasionally found in cocoanut topes mixed with banana clumps in parts of Mysore State. Owing to heavy rains or ample supply of moisture, and favoured by the high relative atmospheric humidity and rich soil, as well as by manure applications, these citrus trees seem to show no deleterious effects in such mixed plantations. Such plantations are neither feasible nor possible on the drier sections of South India.

Cover crops which are intended mainly to prevent soil washing are specially desirable in sloping grounds in the rain-fed areas. Where the loose-skinned oranges are found mixed with coffee, soil washing is often prevented by other measures such as the digging of drains at intervals. On the other hand, in pure plantations of this orange, there is not even the impediments of the closely set coffee bushes, and therefore, the sod system of cultivation involving the turning in of weeds or grass occasionally in a relatively dry period of the year, or the raising of a thick carpet of cover crops during the heavy monsoonic weather is essential.

GROVE CULTURE

Orchard soils are cultivated chiefly to remove weeds, which compete with the trees for moisture and plant foods and for incorporating manures. In some cases soil culture is also necessary to raise intercrops. The old belief that orchards require clean culture all the year round is now proved false. Such a practice depletes plant food and leads to destructive soil washing, rendering the trees worse for the treatment.

Frequent and specially deep tillage or digging of orchard soils is also harmful, in that they lead to much root injury. Deep ploughing or digging should therefore be done only prior to the planting of trees.

The removal of weeds is specially important in summer, when the trees should have all the moisture to themselves. Since cultivation in summer is neither possible always nor desirable, since it would increase the loss of organic matter, growers should attempt either to grow an intercrop in that season or complete the soil culture before the summer sets in. Intercrops are only possible during summer where irrigation water supply is ample. During the rains, intercropping is also desirable to prevent excess of weed growth. Working of the soils during rains when soil is wet should, however, be avoided.

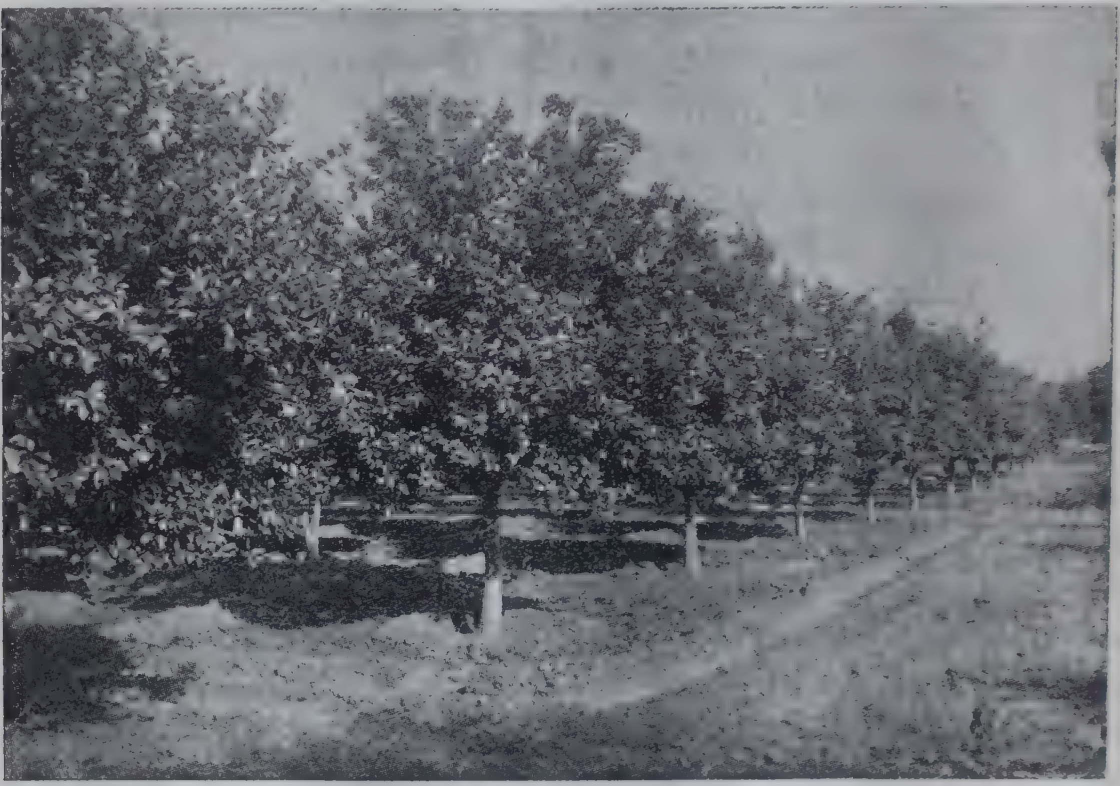

Fig. 63. A seedling Sathgudi orchard under clean culture.

From a consideration of the above points, it would be found that normally, the main ploughing or digging of the orchard should be done during the period when the trees are least active. In citrus, this period would be roughly in December. If the culture is thorough at this time, weed growth cannot occur during the ensuing summer, except perhaps in the irrigated basins. In such places shallow hoeing with hand tools or Junior Hoes, may be all that will be necessary. These need not go more than about two inches deep, while the dormant soil culture may be up to six inches depth at the most.

During the rainy season that follows, shallow hoeing may occasionally be done, with the raising of inter or green manure crop.

For these the soil should be shallow ploughed in a dry period when it is not wet, and seeds sown. The green manuring and soil culture following the intercrop harvest may also be done by employing shallow ploughing.

Three hand weedings are commonly done in mandarin orange plantations in Coorg, Wynad and such heavy rainfall areas, in June, August and December respectively. One or two deep soil diggings may also be given, of which November or December digging is the more common.

In all methods of soil culture by bullock power, injury to the trees by animals or ploughs should be guarded against. Wire or bamboo or other cheap wooden cages should be put around the trees in the rows between which the tillage is done. The cages may be detachable and may be shifted from row to row as the tillage progresses from one part of the orchard to another.

PRUNING

Evergreen trees require as a rule a minimum of pruning and this is particularly true of the *Citrus*. There exists some controversy as to the best method of training and pruning the various varieties and species of *Citrus*. Work on this subject is yet to be done on a comprehensive scale in so far as South India is concerned. In the early stages all that the trees may require is some formative pruning in order to establish a strong frame-work that will enable the trees to carry large crops of fruits when they are older. Special attention may be given to this during the first two or three years for the selection of the frame-work of the trees. Three to four main scaffoldings may be selected, and these should be distributed as evenly about the trunk as possible. If this is done early, and those branches that are not wanted are repressed by pinching or thinning, it will not be necessary to head-back these main leaders. When the frame-work branches are established, the only pruning that is necessary is the removal of suckers or the unusually vigorous water-sprouts. Excessive pruning of suckers is not a practice to be advocated, as this may stimulate the formation of more sucker growths. Often suckers are useful, in that they can be induced to form a permanent scaffold limb, but in all such cases the suckers should be dealt with when young. As the trees grow older, occasional removal of older parts to provide for the gradual renewal of the bearing area, may be necessary, but this must be done gradually. The lower branches generally bear fruits of poorer quality and these may therefore be removed, but the budded trees should be pruned only to a foot high to be just free of the lowermost branches.

However, the best policy to follow especially with young citrus trees is to leave them to themselves when in doubt. Much loss has, however, occurred in the past from the failure to remove rootstock sprouts in time. These being naturally more vigorous than the scion, soon overtake the latter, smothering the same in due course. Numerous growers have unjustifiably been blaming the nurserymen for defective plant supplies, when actually they are themselves to be blamed for neglecting an essential operation, no doubt due to ignorance. If a monthly inspection of each tree is made, it should be possible to keep such unwanted growth in complete control. As soon as any growth emerges from below the bud-joint, or sometimes as it happens, on the rootstock stem portion on the side opposite the inserted bud, that growth should be removed promptly. In all well-kept orchards, even a daily inspection of the tree is done to remove white ants and citrus butterfly caterpillars, as well as to spot out any unexpected malady. The removal of stock sprouts and of dead or diseased wood can easily be attended to without much labour and efforts in the course of such rounds.

Between the *Citrus,* it is extensively believed that lemons require pruning to a greater degree than oranges and grapefruits. In most young lemons the branches tend to grow long without producing side branches and bulk of these are so low-hanging that they practically rest on the soil. A few of these are therefore best removed as they emerge out, but excessive pruning may dwarf the trees and should therefore be avoided. In older trees also, the long shoots which have borne fruits at the extremities may be usefully headed back by turns to the lower secondary shoots, to develop a bearing region close to the ground. Annual light pruning has been recommended by workers in California for the lemon, with a view to stimulate new growth to maintain production. Such pruning may consist of the removal of short growths which have already produced fruits for some years, and thereby stimulating strong new growths which provide the desirable new fruit wood. This general renewal of the bearing surface helps to prevent the early decline in bearing.

With sweet oranges like Sathgudi, the Californian advice is to do as little pruning as possible to normally growing trees.

Removal of suckers is not being recommended now in oranges or in any citrus trees, except when such growths become very dense. Removal of dead wood from orange and all other citrus trees is recommended to make picking and pest control easier and the tree appearance more attractive. Removal of large dead branches also helps to fill up blank spaces with green leaves. The operation of pruning off dead wood also gives an opportunity to the grower to examine each tree very closely. Very tiny dead twigs will cost a great deal to remove and may be left out except in limes or

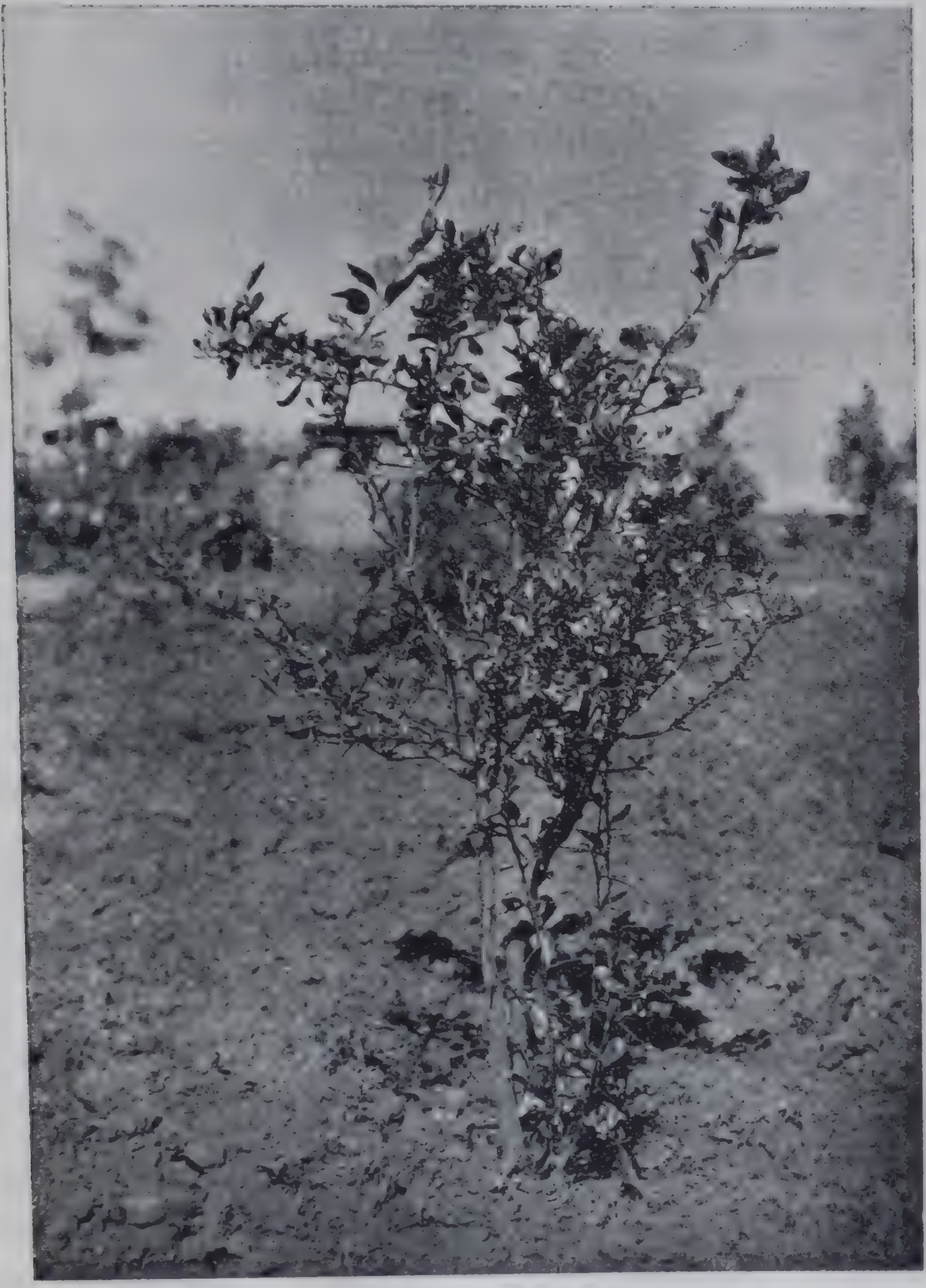

Fig. 64. A citrus tree showing neglect typical in many private groves, untrained and with unpruned stock sprouts.

trees affected by die-back, wither-tip or canker. It is now believed that dead wood has no adverse effect on yield and quality of fruit, but this does not mean that it should be left undisturbed. In certain diseases the dying back of twigs is progressive and is best arrested as soon as possible. In others dead wood may cause also a great deal of mechanical injury to fruit.

In budded orange trees, much fruit in early stages is produced on low-hanging shoots. When these shoots are large, they interfere with cultivation, but if only lighter branches are permitted to remain near the soil surface and the fruits on these are propped above the irrigation water level in the basins, it may add substantially to the yields.

Root pruning as a citrus orchard practice is undesirable and is not recommended. Excessive cutting off of roots either by deep ploughing or by special hand tools is dangerous to the health, and sometimes even to the life of the trees. Root pruning causes a check to growth, and if performed annually, may lead to a progressive deterioration in health and yield, and a marked decline in the life of the trees. The operation should never be done in weak or neglected plantations, and during summer, or in an active growing season. It is also risky to resort to root pruning in a plantation which is producing normal quantity of fruits.

Occasional light root pruning may, however, be desirable in cases of extremely vigorous and shy-bearing trees, in order to convert the excess of vigour into fruitfulness. In such cases soil may be dug out in December-January before the blooming period, to a depth of about nine inches, taking care not to disturb the soil immediately around the tree trunks up to a radius of about three feet. In localities subject to high winds, the tree should be supported with artificial props during the operation. The bigger supporting roots should not be injured. The dug-out soil should be thrown back to its original position within a week of the operation, and the trees should be irrigated immediately afterwards. Fresh or artificial manure should not be added so as to be in contact with the cut roots. If this operation does not force the trees to produce blossoms within a month, it will be idle to repeat the treatment in subsequent years.

A trial conducted at Kodur on the pruning of acid lime trees has revealed that in the first few years at least any cutting back of shoots or thinning of the top depresses the yield. In the lemons, on the other hand, removal of all naturally formed layers from low-hanging shoots do not seem to affect the tree yields adversely. With seedling Sathgudi orange trees, the widespread practice is to remove all growths up to about three feet from the ground level. The same practice is also resorted to by some loose-skinned orange growers in the rain-fed citrus sections. These are undoubtedly helpful in making grove culture easier, but they also tend to delay bearing to a certain extent.

CROPPING

The sweet, loose-skinned and Vadlapudi oranges in South India produce two crops a year regularly with a variable third crop in some seasons. The blossom for the main crop of Sathgudi occurs from December to April, depending upon the weather conditions, and the harvests last from the following November to March. For the off-season crop, flowering occurs from September to the beginning of December, and the fruits are harvested from the following June to November. The Batavian oranges in the Circars are in season from July to December while the Vadlapudis are in season from August to January for the main crop and from February to May for the off-season or second crop. Prevailing prices in the market offer an inducement to the growers to pick immature fruits, while in some years particularly in the Circars with Batavian premature harvests are necessitated by the attack of fruit moth, *Ophideres*. To prevent the attack, basketing of fruits with cheap palmyra leaf baskets is common in the Circars, as a result of which the fruits become prematurely and irregularly pale yellow in colour. The unbasketed fruits of Sathgudi oranges remain green when immature, the fruits developing the best golden yellow or orange colour only in the main harvests in December to February. The ability to retain mature fruits on trees is dependent on the environments; orchards in some places being more suitable for late harvests than those located a few miles away. The third crop of Sathgudis which is harvested between March to June is from occasional bloom that appears from June to September. These fruits are also green and inferior in quality, though fetching a good price, because of their appearance in the markets in scarcity periods.

The proportion of yields in the three seasons varies greatly from year to year, depending particularly on the weather conditions at the time of or just preceding the blooming season for each crop.

There is also considerable variation from orchard to orchard, possibly due to variation in grove practices, while huge differences between individual trees, possibly due to inherent character, are not also uncommon. Actual records during a period of four years show that the off-season crop accounts for one-fifth to about one-third of the gross harvests in a year. It is widely believed that a good off-season crop can be secured if severe drought conditions prevail during some weeks before the flowering for the crop is due to commence, and heavy rains occur during the fruit development period for this crop. In normal years and under timely irrigation practices, the Sathgudi trees yield both the main and off-season crops. The occasional failure of the main season crop may increase the off-season crop set and size. It has been noted that in some parts of the Circars, Vadlapudi trees fail to bloom towards the close of the year, as a result of which no summer crop is produced. Root pruning or withholding of water to the orchards, or manuring and deep soil culture may also lead to the regulation of crop in each season, but these are rarely done in South India with the specific purpose of securing harvests in a particular period of the year, as is done in the Central and Western India.

The loose-skinned oranges of South India also yield two crops a year fairly regularly from most of the trees. Coorg has the main crop harvests from December to April, and the off-season crop from July to September, with a small third crop in September. This also applies to parts of Mysore and Wynad, though in Wynad summer harvests are scarce, the crop being over by January. In the Circars, October to January is the main season, while in Kallar Government Fruit Station on the lower foot of Nilgiris, the main harvest season extends from August to October and the off-season harvests from February to March. Here the latter crop varies from one-fourth to almost equal of that of the main season crop, depending on the weather conditions.

On the Sheveroys only one cropping season is recognised, it being from October to December, while on the Lower Palnis there are two seasons, one in August-September (*Kodai* crop), and December-January (*Kalam* crop).

Limes are in harvest throughout the year in South India. The season of maximum harvests, however, is limited to March to April in the Circars, July to September in Rayalaseema, June to August in Madura and North Arcot, April to June in Guntur and Nellore and January to March in Tinnevelly. At Kodur it has been found that about 80 per cent. of the year's crop is harvested from May to August, 14 per cent. from January to April and 6 per cent. from September to December.

Pummeloes, grapefruits and citrons are in season generally from August to December, August to November and August to November respectively at Kodur. The lemons yield 70.0 per cent. from May to September. Kumquats can be harvested all through the year, with maximum harvests from July to December.

Reliable figures relating to the yields of South Indian *Citrus* are not available. With Sathgudi oranges, the mean yields per tree have averaged in a private seedling orchard to roughly 600 fruits. In good orchards, an average annual tree yield of 1,000 fruits is considered normal, while 1,500 to 2,000 fruits as very good. Full-grown budded Sathgudi trees may not differ in this respect from the seedlings. Commencing to bear from about the fourth year of planting, an yield of over 800 fruits have been harvested from budded sweet oranges at Kodur in the eighth year. According to an estimate in the Report on the Marketing of Citrus Fruits in India, the acreage yields in South India are put at 90 to 120 maunds for Batavian oranges, 90 to 100 maunds for Sathgudi oranges, 200 maunds for Vadlapudis, 150 maunds for loose-skinned oranges grown at Coorg and Mysore and possibly for those in Wynad as well, 225 to 300 maunds for acid limes, and 180 to 400 maunds for pummeloes. A tree of pummelo is reported to have yielded a crop of 2,000 fruits in a year at Devanahalli village in Mysore State. For mandarins, the maximum tree yield as reported by a leading grower in Titimathy in Coorg is 5,000 fruits in a year. For lemons the yields have been as heavy as 634 to 825 fruits per tree at Kodur by the eighth year of planting, while acid limes of the same age had begun to yield over 1,000 fruits from some trees by that year, grapefruits about 200 fruits, pummeloes only about 60 fruits, citrons about 350 fruits, and kumquats above 1,500 fruits from some trees. In years when wet weather did not interfere with the blooming in February the individual pummelo tree yields at Burliar Fruit Station averaged about 60 lbs. to 112 lbs. per year and grapefruits from 24 lbs. to 73 lbs. At Kallar the loose-skinned orange yields have averaged from 108 to 181 lbs. per year. Marsh Seedless grapefruit is reported to have yielded about 1,000 fruits per tree per year in full-bearing age at Penagalur, and pummeloes over 300 fruits in several places.

PICKING AND PACKING

It is well known that citrus fruits have to be picked when they have developed their characteristic flavour to the maximum extent. The optimum maturity stage for harvest has been found difficult to be fixed for seedling orchard produce as well as for the variable lower quality off season fruits. It is customary to harvest fruits in South India according to the prevailing demand and at one time; and this often leads to the mixing up of good and poor quality fruits, and mature and immature ones in the same lot, with disastrous consequences to the purchaser as well as to the reputation of the industry.

At the time of harvest it has been suggested that the fruits should not be pulled off from the trees, as this may injure the branches as well as lead to fruit damage before it reaches the consumer. Clipping is therefore recommended, particularly in sweet oranges. With acid limes and seedling trees of loose-skinned oranges, pulling off the fruit with the help of long bamboo pole with a scythe attached to one end, is sometimes done. This is a

Fig. 65. Harvesting of acid lime fruits.

cheaper and more convenient method than clipping, especially in old plantations. Provided such pulling does not tear away pieces of the rind, as it often happens with loose-skinned oranges, and a net is fixed to the harvesting end of the bamboo pole to catch the picked fruit, it need not be necessarily condemned, as is often done. It is reported that fruits harvested by pulling or by snapping the stalk with hand have an advantage in the control of the stem end rot, since the method enables the removal of all stalk portions at a later stage, thereby removing infections believed to be harboured in the twig near the stem end. Sweet oranges and grapefruits can also be pulled off the tree without tearing the skin, but in all such methods of picking, clipping of the stalk to a 'button' is helpful to prevent damage to other fruits inside the packing case or basket, and also to convince the purchaser that the fruits are not tree-drops but actual harvests from the tree.

Suggestions have been made that citrus fruits should not be picked during rains or two to five days after, or when the fruits are covered with dew. In heavy rainfall areas such picking has been done always for sale in neighbouring markets without any apparent harm. Theoretically the turgid citrus fruits in a wet condition liberate oil from their rinds causing some unseemly spots. Prolonged wet weather is also believed popularly to make the fruits watery and less tasty.

Handling of citrus fruits is required to be done with great care at all stages from picking to the marketing. Else, there is likely to be considerable wastage in fruits by the time they are consumed. The picked fruits should be gently placed in baskets and packed with care to avoid any damage to the skin or contents. The practice of transporting of fruits loose from the orchard to the markets or assembling yards or sheds, in lorries or carts, is open to the risk of causing a great deal of damage.

In many countries the picked fruits are stored for a few days before grading and packing so as to wilt or cure or quail the fruit. This is said to reduce wastage. Under South Indian conditions, particularly in dry periods of the year, such a practice may lead to a rapid loss of moisture and fruit weights, causing unseemly shrivelling of the skin. In any case the picked fruits should not be exposed to sunshine. Rapid packing after harvest may be advisable in seasons where high temperatures and low relative humidity tend to cause excessive loss of moisture from harvested fruits.

In the packing shed it is also the practice in some countries to subject the fruits to a borax or other antiseptic treatment so as to control mould and stem end rot. Green fruits are also sometimes artificially coloured by ethylene or stove gas treatments to make them yellow or orange-coloured. A wash with dilute caustic soda is also sometimes given to loosen scale insects and remove surface dirt, after which the fruits are washed clean with water sprays and brushed and polished. Culling of bruised or otherwise undesirable fruits follows, and then the sound fruits are graded by machinery into different sizes. In South India none of these steps are in vogue. The harvested fruits are now being graded in a few places after a slight rubbing of the skin with a cloth piece to remove dirt and to give a lustre, but most growers are content to pack the fruits after only a rough grading by hand and without any pre-treatment. A simple grading plank devised by the Madras Agricultural Department has been found to be very useful in separating out Sathgudi oranges and limes to four different sizes. With some modifications, this machine may also suit loose-skinned oranges and Vadlapudis as well.

In most other countries the graded oranges are wrapped in thin tissue papers before packing. Waxed papers or cellophane wraps have also been used for fancy trade and to conserve moisture. The packing boxes and crates are of wood and of different dimensions. Some of these have been sketched and described by the author in a separate publication. In South India, baskets made from split bamboo or dried branches as of mulberry are the common containers used. These baskets should be strong and, if possible, of uniform dimensions. The bucket-shaped, round-bottomed baskets have a disadvantage, in that they occupy more space in railway wagons and lorries and cannot be stacked with stability. Whatever the method of packing be, the fruits inside should be laid in a manner to give a tight pack, such that would permit shrinkage of the fruit without giving a loose pack at the destination. The tight pack is therefore so made as to form a bulge on the lid, which disappears by the time the pack reaches the destination, at the same time retaining the tightness.

The exact time for picking oranges is usually determined in most countries by the sugar (total soluble solids) and acid contents of the fruits. In U.S.A., 8 to 1 ratio is largely followed, while in South Africa the ratio varies from 6.5 to 1 for Navels, 6 to 1 for Valencias, and 5.5 to 1 for seedlings. Neither these maturity tests give an exact indication of the palatability nor of the juice content. Some countries, however, have laid down a minimum of 42 to 45 per cent. of juice content by weight, for the purpose of export. Analytical studies of Sathgudi oranges done at Kodur on the basis of these various standards have been reported in a separate publication. It seems now that, till budded plantations become the rule in South India, an effective grading on the basis of quality may not be feasible.

Throughout this country citrus fruit is transported by rail as ordinary cargo and without refrigeration. Under such conditions, fungal wastage, reduced weights due to loss of moisture, skin spots, etc., often result. Cold storage or well-ventilated, non-refrigerated holds with a constant flow of air maintained by funnel ventilators and fans, are provided in trains or steamers in many countries. Pre-cooling plants are also installed in some countries at the shipping ends in order to cool the fruit rapidly to the temperature of transport. So far these facilities are neither available nor have been actively demanded by the South Indian producers or the citrus trade.

ECONOMICS

As in the case of other fruits, it is not possible to present yet an accurate idea of the production costs of any of the citrus fruits. The figures furnished below may, however, serve to give a rough idea. These have been gathered at the Fruit Research Station, Kodur from experimental areas. In both cases intercropping of the orchards could not be done, as that was thought to introduce a vitiating factor in the experiment. In the case of Sathgudi orange, an exceptionally severe incidence of root-rot has also served to prevent the receipts from being what they should have been. Above all, this area having a poor soil with possibly more than the normal content of calcium carbonate, cannot be taken as typical of the sweet orange soils. Though these factors have served to cause delayed bearing and very low yields, the production cost of the tree is not expected to be influenced appreciably thereby. With lime on the other hand, the figures relating both to their production costs and receipts can be deemed as providing a fairly accurate index.

Table No. 3:—Showing the Production Costs under Major heads, from a Plantation of Sathgudi Orange Planted in 1938 to 162 budded trees and 18 seedling trees in an area of 4·44 acres.

Particulars	Preparatory cultivation in 1938	October 1938 to April 1939	1939-40	1940-41	1941-42	1942-43	1943-44	1944-45	1945-46	Total
1	2	3	4	5	6	7	8	9	10	11
1 Manual labour	98 10 9	48 1 0	78 4 6	136 2 6	140 0 6	129 7 4	169 13 7	284 10 4	184 1 0	1,269 3 6
2 Bullock labour	145 9 1	24 8 0	10 0 0	...	48 1 0	19 7 0	79 9 9	61 5 9	75 4 0	463 12 7
3 Irrigation	...	28 2 0	120 11 9	50 14 6	81 8 0	93 15 0	134 1 6	194 5 6	164 5 6	867 15 9
4. Manures	...	...	5 2 0	31 0 0	52 4 0	66 1 6	128 1 11	234 14 0	125 6 3	642 13 8
5 Other expenses	8 9 0	8 9 0	40 8 0	19 3 0	23 10 3	46 11 6	52 13 10	98 4 5	49 11 4	348 0 4
6. Cost of plants	143 0 0	...	...	...	...	...	...	...	...	143 0 0
Total:	395 12 10	109 4 0	254 10 3	237 4 0	345 7 9	355 10 4	564 8 7	873 8 0	598 12 1	3,734 13 10

Col. 12 - Remarks: -

1. Manual labour :- Digging channels, forming bunds, digging with *mummuties* around trees, weeding, hoeing etc.
2. Bullock labour :- Ploughing, working *guntaka*, *gorru*, levelling board, bund-former.
3. Irrigation by engine, Persian wheel and guiding water.
4. Cost of manures and cost of application.
5. Cost of watch, care of plants, spraying against diseases, pruning dead shoots, etc.

Table No. 4 :—Showing the Production Costs under Major heads and Profits from an Acid Lime Grove containing 54 budded trees and 18 seedlings, all Planted in 1938 in an area of 1·0 acre.

Particulars	Preparatory cultivation in 1937-38	Obtober 1938 to March 1939	1939-40	1940-41	1941-42	1942-43	1943-44	1944-45	1945-46	Total
1	2	3	4	5	6	7	8	9	10	11
1. Manual labour	118 14 2	4 12 0	27 6 0	63 12 0	44 11 0	31 2 0	44 10 6	33 11 9	48 10 9	417 10 2
2. Bullock labour	53 10 2	6 0 0	10 3 0	...	2 4 0	1 5 0	1 4 0	...	...	74 10 2
3. Irrigation	1 15 0	5 10 0	34 1 0	25 10 0	31 5 0	41 0 8	53 2 10	71 3 10	69 11 3	333 11 7
4. Manures	...	...	16 3 0	17 4 0	19 0 0	24 6 7	15 10 8	106 2 1	82 6 0	281 0 4
5. Other expenses	0 10 0	4 4 6	6 14 6	10 8 0	30 9 0	28 7 0	22 4 0	72 4 6	22 14 0	198 11 6
6. Cost of plants	75 0 0	...	...	...	...	...	...	...	...	75 0 0
Tatal :	250 1 4	20 10 6	94 11 6	117 2 0	127 13 0	126 5 3	137 0 0	283 6 2	223 10 0	1,380 11 9

Col. 12 - Remarks : -

1. Digging channels, forming bunds, digging with *mummuties* around trees, weeding, hoeing etc.
2. Ploughing, working ***guntaka, gorru,*** levelling board, bund-former.
3. Irrigation by engine, Persian wheel and guiding water.
4. Cost of manures and cost of application.
5. Cost of watch, care of plants, spraying against diseases, pruning dead shoots, etc.

A net profit of about 59.0 per cent. from limes was secured in 1945-1946, i.e., within eight years of planting; and this is an indication of the profitability of this crop when grown under normal conditions as those at Kodur. With Sathgudi the record gross income so far reported is that of a grower near Chitvel in Cuddapah district, with Rs. 166|- per tree in one year. A net income of Rs. 1,500|- per acre from Batavian orange farming has been realised by an owner of a budded plantation in its eighth year only. From loose jacket oranges, a leading grower at Titimathy in Coorg reports to have earned an average gross income of Rs. 800|- per acre in 1946. His average tree yield worked out to 1,000 fruits.

Storage :— Normally, the citrus fruits have all a good keeping quality, such as to enable them to be marketed without any risk of damage in any of the leading markets of the country. Cold storage trials at the Punjab have shown that sweet oranges and grapefruits stand well there up to 4½ to 5½ months respectively at a temperature ranging from 36 to 39°F, while the loose-skinned oranges could be kept only for four to five weeks at that range. In Poona similar trials have shown that sweet orange does not show any wastage for about three months at a temperature of 52°F. The acid lime could be held for a month at Poona at the ordinary room temperature which was 70 to 100°F, but at 52°F in the cold storage these fruits kept well for two months.

Products :— A large-sized lime squash and cordial industry that has been built up in the country during the past few years is mainly depending on South India for the raw produce. Lime pickle is also a product of popular demand in households. The dried lime peel powder is a good product for cleaning brass vessels, for which purpose fresh limes that are unfit for sale are now being widely used. Lime oil is another commercial product of some potential importance, while lime jelly and marmalade have long been known to be of high class. Lemons lend themselves for all the above industrial and domestic uses, yielding perhaps even a richer flavoured squash and home-made sherbat. Sweet orange squash and orange peel oils are well-known products in good demand. The peel oils are also prepared from Kichili, Vadlapudi and sour orange. All these fruits too give good quality marmalades and jellies. Citron peel and kumquat candies are highly palatable products, the former being especially in demand for making of cakes. Canned loose-skinned oranges and squashes of the same fruit are possibilities that are yet to be exploited. Marmalades and jellies of these also may be of some promise, especially if blended with other citrus. Grapefruit squash is a well-known product much fancied by some persons.

PESTS AND DISEASES

From the information secured largely from the Entomological and Mycological Sections of the Madras Agricultural Department, the following brief notes on citrus pests and diseases are compiled.

PESTS:

1. CITRUS BUTTERFLY :—(*Papilio demoleus* and *P. polytes*) The caterpillar of this butterfly is a most troublesome consumer of citrus leaves, causing terrible damage to young plants in seed and nursery beds as well as in the orchard. They are, however, of no consequence in older trees. The young caterpillars resemble in colour and shape the birds' droppings, but later they are leaf green and about two inches long and cannot easily be distinguished from their resemblance to the leaves. Similar insects damaging the leaves are also known as orange dog in some countries. Many defoliated plants in neglected nurseries and young orchards stand testimony to the havoc caused by the insects. Daily hand-picking of the caterpillars both in very young and older stages is necessary for destroying them. The picked caterpillars may be put in a small receptacle containing water with a small film of kerosene oil, or they may be killed by trampling on them. Spraying the plants with calcium arsenate at one oz., in 2½ gallons of water has also been suggested as an efficacious treatment.

2. FRUIT SUCKING MOTH :—(*Ophideres fullonica* and *O. maternae*) The adult moths drill holes on the fruits with their proboscis during night time and feed on the juice. This results in the dropping of the affected fruits or their rotting. When such damaged fruits are pressed by hand the juice spurts out through the holes made by the insect. It is a serious pest in the Circars as also in parts of Rayalaseema and Central districts. The pest has an alternate host plant in *Tinospora* sp and also feeds on tomato crops. Raising of these to lure the moths, as well as catching and destroying them at night with the aid of a powerful torch or other light have been suggested. Basketing the immature fruits with cheap palmyrah leaf baskets of size slightly larger than a mature fruit is also commonly done in the Circars. This lessens the damage, though leading to a premature colouring of the rinds giving the fruits a false semblance of maturity.

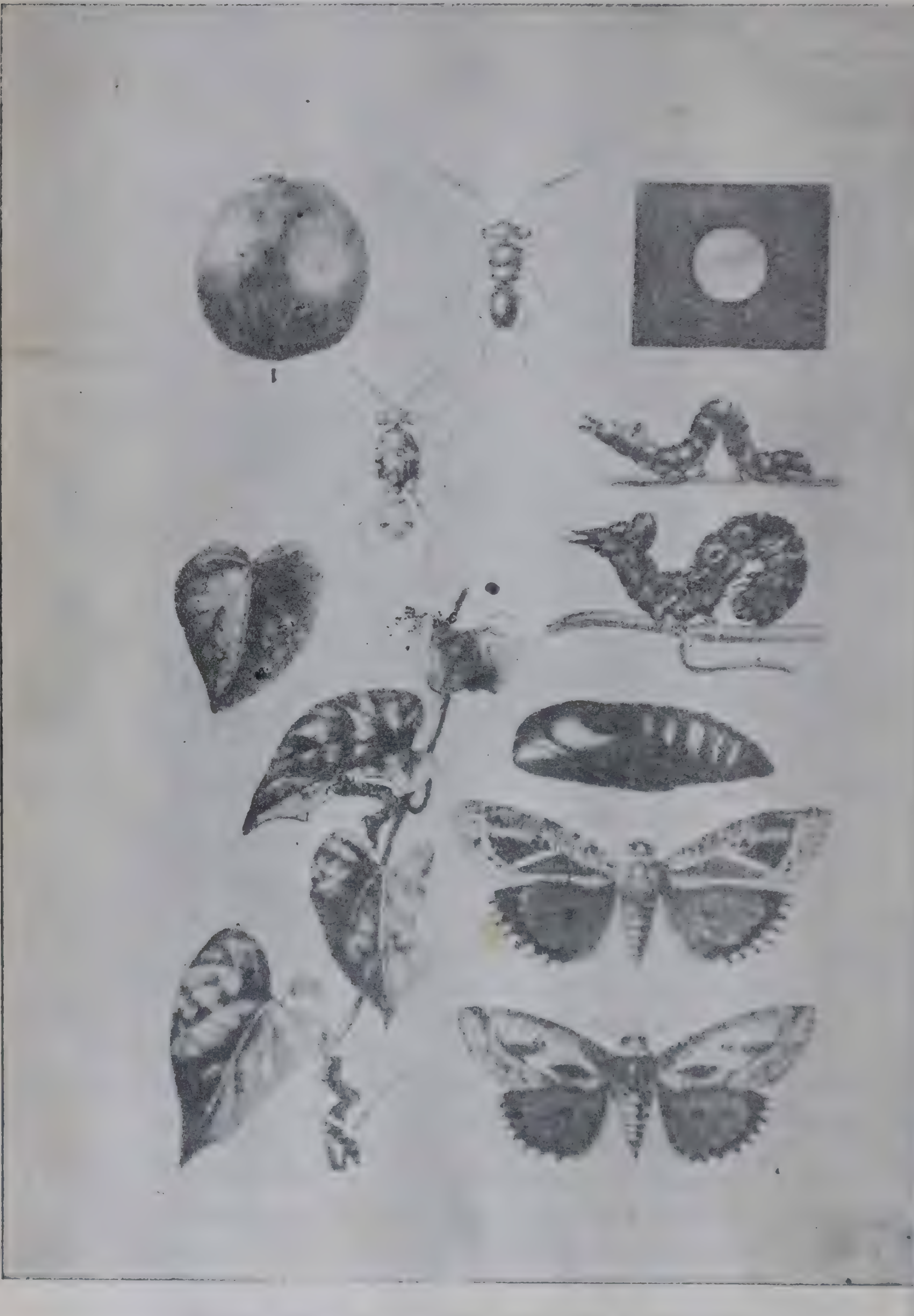

Fig. 66. Some common citrus pests with a host plant. (*Courtesy of the Government Entomologist, Coimbatore*)

3. FRUIT FLY :—(*Dacus incisus*) The maggots of this insect feed inside the fruits and spoil their taste and sale value. The damage generally occurs in fruits retained on the trees late in the season and long after maturity stage. It is not a serious pest in South India, as it is with the mangoes. Spraying crude oil emulsion at 1 lb. in 10 gallons of water may prove a deterrent to flies from laying eggs. As the maggots pupate in the soil, raking of the soil in the orchard may be done to destroy the pupae.

4. LEAF MINER :—(*Phyllocnistis citrella*) The tiny caterpillars bore mines into the leaf tissue, making the leaves curl and fade. In severe cases of attack the plant becomes unsightly. Spraying with nicotine sulphate at one fluid ounce in about five gallons of water (0.1 % strength) or with fish oil rosin soap of 1.25 % strength are advised.

5. SHOOT AND FRUIT SUCKING BUGS :—(*Vitellus orientalis*) These suck sap from tender shoots and fruits and induce fruit shedding. It is not a serious pest and the remedy also is not worked out yet.

6. COTTONY CUSHION SCALE :—(*Icerya purchasi*) This has been noted only in stray trees in a few places in South India. Spraying is ineffective, but certain parasites are said to keep the pest in check. To prevent the spread of this pest, citrus plant material is prohibited from export outside Madras Presidency by quarantine regulations.

7. SOME APHIDS :—(*Aphis* sp.) These occasionally attack the foliage and fruits, which are sometimes rendered unsightly by mites.

Mealy bugs and other insects which secrete honeydew and cause sooty mould on shoots, leaves and fruits are dealt with separately. Termites or white ants often attack the tree stems and branches, but can be kept off by removing all dried sticks and material from the orchard, locating and destroying the queen ants and smearing the tree trunk with Bordeaux paste to serve as a deterrant.

DISEASES:

1. MOTTLE LEAF :—(*Foliocellosis*) This is the most widespread disease caused by either deficiency of zinc in the soil or its unavailability to the plants. This and other types of deficiency diseases have been already dealt with under manuring of

citrus trees. All these deficiency diseases result in the loss of chlorophyll from the leaves, a symptom also caused with some variations by other diseases like root-rot and water-logging in the soil. Primarily a physiological disease, it may also be caused to a lesser extent by defective soils and grove cultural conditions or organisms. The treatments vary according to the causal factors, which have to be determined first. Spraying with zinc sulphate-lime-mixture in the proportion of 10 lbs. of zinc sulphate, 5 lbs. of lime and 100 gallons of water, one or more times, at intervals of about a month cures this particular deficiency disease.

2. DIE-BACK AND WITHER-TIP :—These are two separate diseases and both result in drying up of leaves and twigs from the tip. With the shedding of leaves and death of the terminal parts or sometimes of entire limbs, the trees appear bare with a mass of brownish dead wood. The tree growth and bearing capacities are adversely affected. Wither-tip is said to be caused by a fungus, *Colletotrichum gleosporoides* on some *Citrus* and by a *Gleosporium* sp on acid lime. The disease specially affects lime trees by killing of small twigs in abundance, while in other citrus it may cause brownish spots on fruits. Removal of dead twigs frequently, applying Bordeaux paste to cut ends and spraying with Bordeaux mixture have been suggested against wither-tip attack. Restoring the tree vitality by manuring and removal of dead wood frequently helps greatly to prevent damage in excess. Die-back has been shown previously to be caused sometimes by copper deficiency in the soil. Stiff, ill-drained and water-logged soils also bring about die-back in citrus. In such cases, effective drainage often brings about tree amelioration. Such improved grove practices may be combined with pruning of dead and diseased wood, followed by a spraying with Bordeaux mixture.

3. CANKER :—(*Pseudomonas citri* or *Phytomonas citri*) Brownish, corky eruptions are formed on leaves, twigs and fruits by the disease. Acid limes, some varieties of lemons, sweet oranges and grapefruits are very subject to it, while all the promising lemon varieties like Nepali Oblong and Round and Seedless seem to be very highly resistant. Citrus canker is one of the most dreaded diseases in many parts of the world, and destruction of the affected trees is reported to be the only remedy. It is a bacterial disease and will spread by the agency of birds, animals, human beings, wind, rain, irrigation water or plants and plant materials. In South India the incidence of the disease is fortunately not in a very

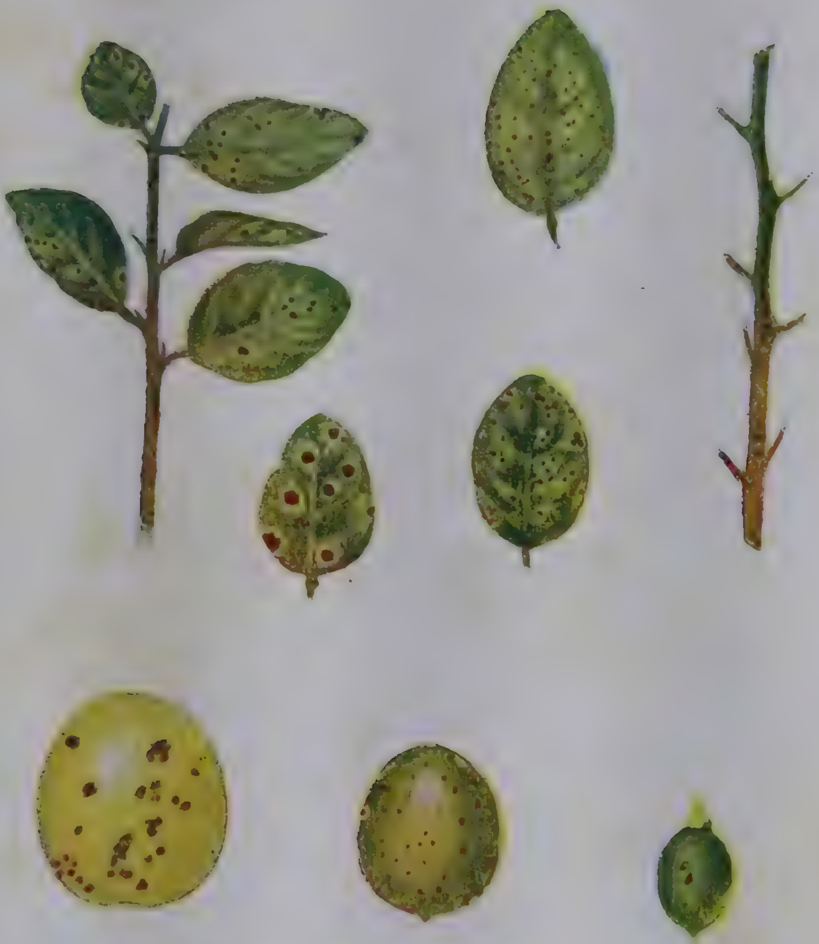

PLATE IV. CITRUS CANKER-SYMPTOMS
(Courtesy of Govt. Mycologist,
Coimbatore)

(To face page 266)

virulent form, and spraying with Bordeaux mixture after removal of diseased parts by picking and pruning, is suggested to be all that would be necessary.

4. MILDEW :—(*Oidium* sp.) This forms ashy-white, powdery growth on leaves and twigs. In severe cases the flowers do not open well, and fruit set is low. Citrus trees in humid tracts on higher elevations, especially the loose-skinned oranges suffer greatly by the disease. Dusting with fine sulphur or spraying with one per cent. Bordeaux mixture on the new flush has been recommended.

5. LEAF AND FRUIT FALL :—(*Phytopthora* sp.) The leaves and fruits are attacked by this fungous disease, and they shed in large numbers, causing heavy damage to loose-skinned oranges in heavy rainfall areas. Instances of a whole crop being destroyed in a season are reported. The affected trees ooze gum from stems and branches. Spraying with one per cent Bordeaux mixture is recommended as an efficacious remedy, and this should be done at the first signs of the disease appearance.

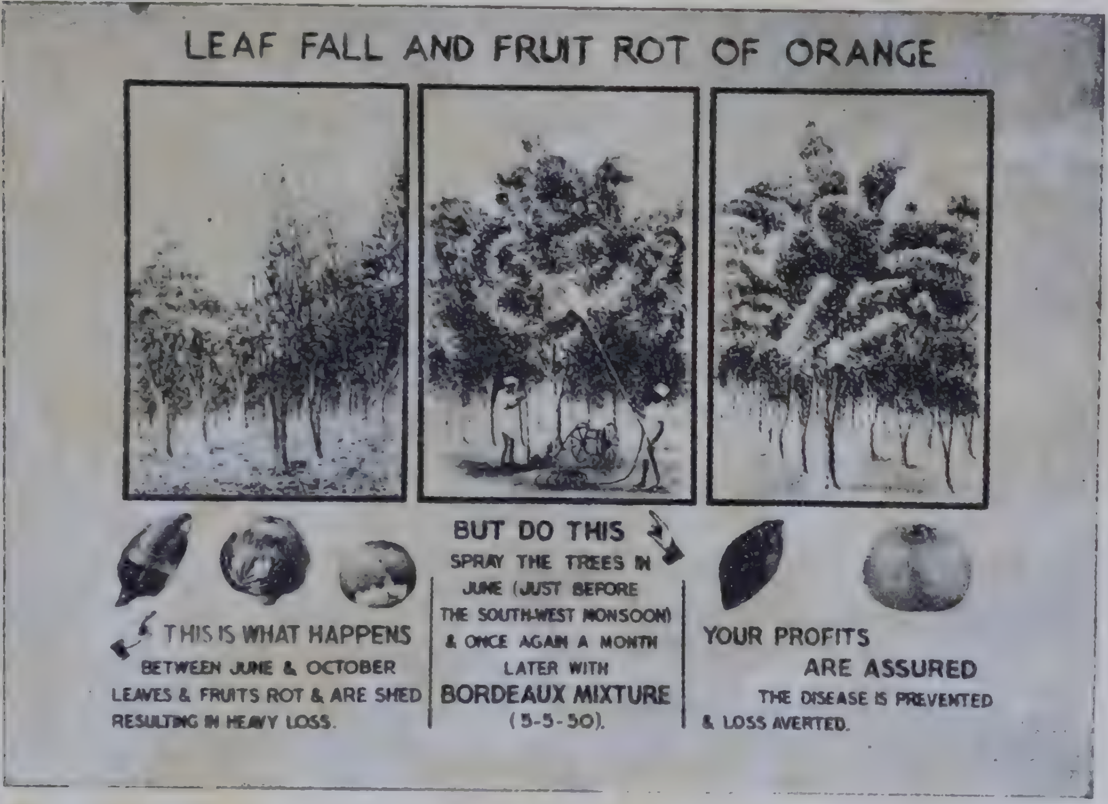
LEAF FALL AND FRUIT ROT OF ORANGE
THIS IS WHAT HAPPENS
BETWEEN JUNE & OCTOBER
LEAVES & FRUITS ROT & ARE SHED
RESULTING IN HEAVY LOSS.
BUT DO THIS
SPRAY THE TREES IN
JUNE (JUST BEFORE
THE SOUTH-WEST MONSOON)
& ONCE AGAIN A MONTH
LATER WITH
BORDEAUX MIXTURE
(5-5-50).
YOUR PROFITS
ARE ASSURED
THE DISEASE IS PREVENTED
& LOSS AVERTED.

Fig. 67. A chart to advise orange growers on the control of leaf and fruit fall. (*Courtesy of the Government Mycologist, Coimbatore*).

6. SOOTY MOULD :—(*Capnodium* sp.) Dense black sooty crusts are caused by this disease on the upper surface of the

leaves, due to secretion of honey-like juice by insects. The trees so affected become less efficient, yielding reduced crops, but fortunately the damage is not heavy and the disease is confined only to heavy rainfall or humid tracts. Spraying with fish oil rosin soap (1.25 % strength) and tobacco decoction (5 % strength) with starch has been recommended.

7. ROOT ROT AND COLLAR ROT :—The true collar rot is said to be caused by *Phytopthora parasitica,* while the dry rot is said to be caused by some species of *Fusarium.* In South India all root and stem diseases are commonly grouped under the name of root-rot, excepting that caused by gummosis. Tree collar rot affects the base of the stem and those of main roots, forming cracks. Trees may become defoliated and may or may not show gum excrescences. The affected bark may peel off the stem and roots. The disease occurs mainly in high water table sites or in water-logged areas and on stiff soils. On the other hand, the dry root-rot occurs both on heavy and light soils and causes decay of the bark and wood of the lower parts of the stem and main roots, eventually causing tree death. Besides water-logged and ill-drained conditions, both may be aggravated by low planting of trees, bark or root injuries, accumulation of moist soil in a heap around the trunk and prolonged contact of moisture with the trunk. Sour orange is said to be highly resistant to these diseases, rough lemon only slightly resistant, and lemons, limes, sweet oranges and citrons highly susceptible, but limes and lemons seem to have suffered the least in South India. Vadlapudi orange is known to be also very susceptible to it and has suffered very greatly from root-rot in Kistna and Godavary deltas in high water table and water-logged sites. Removal of the soil around the base of the trunk, scraping of the dead bark with a little of inner tissue and applying a lime sulphur solution have been advocated. Bordeaux paste may be smeared over the treated root and stem parts as an alternative. Exposing of the crown roots to the air for about a foot from the trunk has been advocated by some workers. Collar rot is known as mal di gomma in some countries.

8. GUMMOSIS :—This disease in South India is probably similar to the *Phythiacystis* gummosis reported from other countries. It causes gum oozing on the trees. Scraping of the affected parts as soon as signs of gumming are noticed, followed by application of Bordeaux paste to the region is helpful in checking its spread. If prompt steps are not taken, it becomes difficult to check

it and save the trees. Gumming may be caused by other diseases such as collar rot.

9. QUICK DECLINE :—A disease named as *tristeza* or quick decline in Brazil has recently assumed alarming proportions in the citrus groves in several lands. The disease accounted for a large number of deaths in all sweet orange groves on sour orange rootstocks in Argentina and Brazil. Workers in California have expressed their opinion that this is a virus disease and it can possibly be avoided by eliminating the sour orange rootstock entirely in sweet orange nurseries.

10. FRUIT SHEDDING :—In addition to fruit drops due to diseases already referred to above, shedding of blossoms and immature fruits often occur in citrus orchards to an alarming extent, though symptoms of any disease may not be apparent. Some amount of shedding of flowers and young fruit is a natural phenomenon in *Citrus*. but it is only when such shedding is heavy to affect crop size adversely, that it is a matter for concern. Such abnormal shedding of young fruits occurred in 1944 in Kodur area and formed the subject of an enquiry. Although no direct cause could be determined, it appeared that weather conditions largely contributed to it. A sudden variation from wet weather to a dry and hot period or *vice versa* may bring about the shedding, owing to the disturbed water relationship. A high transpiration from the leaves may result in the tree drawing upon moisture from the young fruits to the leaves, as has been shown by some workers in the United States of America. A sudden fluctuation in weather may cause the formation of an abscission layer in the fruit stalk at the base of the ovary, as a result of which the fruits become prematurely yellow and drop off. Hot and dry spells during or immediately after the blooming period are also widely believed to increase the fruit and flower shedding. To an extent, supply of ample moisture during such periods may help to reduce the damage. Green manure or intercrops in the orchard and strong wind-break belts may help to increase humidity of the air and thus minimise the scope for fruit shedding by the sudden occurrence of dry spells.

List of References.

1. Agricultural Marketing Adviser to the Government of India Report on the Marketing of Citrus Fruits in India, Marketing Series No. 43, 1942, Government of India Press, Simla.

2. Naik, K. C.—Some Citrus Nursery Technique Trials at Kodur; Indian Journal of Agricultural Science—August 1939.
3. ,, A Study of Pre-orchard Life of Certain Rootstocks for Chinee orange and Acid lime at Kodur, Indian Journal of Agricultural Science, August, 1940.
4. ,, Orchard Efficiency Analysis in Mango and Sweet Oranges, Madras Agricultural Journal, March, 1940.
5. ,, Promising Fruits, The Villagers' Calendar & Guide; Madras. 1945.
6. ,, Notes on Rootstock for Acid lime, Indian Journal of Horticulture, June, 1944.
7. ,, Rootstocks for Acid lime, Indian Journal of Agricultural Science (In Press).
8. ,, Some Useful Orchard Equipments devised at Kodur, Madras Agricultural Journal, March, 1940.
9. ,, A Study of Orange Marketing in England, Agriculture & Live Stock in India, March, 1932.
10. ,, Lime Beverages, Leaflet No. 5 of Bihar and Orissa Department of Agriculture, 1935.
11. ,, A Note on the Preparation of Lime Beverages, Pamphlet No. 22, of Madras Department of Agriculture, 1942.
12. ,, Plant Selection in Orchard Economics, the Gardener, Vol. I, No. 4, 1938.
13. ,, The Choicest Fruits of India, *ibid*. Vol. II, No. 2, 1938.
14. ,, Future of the Indian Citrus Industry, Madras Agricultural Journal, Vol. XXVI, No. 7, 1938.
15. ,, Hints on the Planting of Fruit Trees, Leaflet No. 118, Madras Agricultural Department, 1943.
16. ,, Hints on Raising Orange Gardens, Villagers' Calendar and Guide, 1942.
17. ,, Brief Hints on Irrigating Fruit Gardens, *ibid.*, 1942.
18. ,, Brief Hints on Manuring of Fruit Trees, *ibid.*, 1942.
19. ,, Fruit Personalities—Sathgudi, *Mezhichelvam* (in Tamil), Madras, January, 1945.
20. ,, Fruit Personalities—Lemon, *ibid.*, August, 1945.
21. ,, Fruit Personalities—Lime—*ibid.*, December, 1945.
22. ,, & S. Sugurappa—Quality Grading of Sathgudi Oranges, Indian Farming, Vol. IV, 5, 1943.
23. Webber, H. J. and L. D. Bachelor—The Citrus Industry, Vol. I, University of California Press, 1946.

CHAPTER III

BANANA.

INTRODUCTION:—Besides its use as one of the most nutritive and popular table fruits of South India, the banana plays an important role in the life of almost every South Indian. Large quantities of the banana find an important place in the culinary art of this part of India, as can be gauged from about 26,000 acres devoted to such varieties in Madras presidency alone. Apart from the fruits, the "heart" and the central core of the pseudo-stem are also widely and extensively used for culinary purposes. The banana leaves form also an almost invariable requirement in a vast majority of South Indian households for use as substitutes for dining plates. Some use is also made of the banana fibre in floral trade, in cordage and cottage scale textile industries. The leaf sheaths and leaves are also being extensively employed as wrapping and packing materials. Banana flour has been found to be a fair substitute for wheat and corn flour and is popular in the West Coast as food for invalids and infants. The banana "fig", conserves, jams, crisps, and chips are a few other popular products of this, one of the most popular of the South Indian fruits. Added to these varied uses is the very important fact that the food production per acre is by far greater from banana growing than through general agricultural or horticultural farming. With yields ranging from 10,000 to 60,000 lb. of banana fruit per acre per annum, excluding hearts and cores of pseudo-stems, as compared to a maximum yield of 8,000 lbs. of paddy in a year from more than one crop, banana growing offers one of the most efficient means of economic exploitation of land for augumenting food production in South India. The ease with which the banana can be grown at a minimum cost of production, almost entirely under rain-fed conditions in certain areas, and its adaptability to a diversity of soil conditions in South India, invests the banana crop with a special importance and a unique status in the utilization of land in this part of the country, where capital is scarce among a large section of landholders. From the market point of view too, the banana has certain advantageous features not enjoyed by other crops, in that it has the ability to produce fresh crop harvests all round the year. All these characteristics have made the banana the proverbial "poor man's food" in the South of India, so that it is grown in a large number of home compounds and in innumerable farms either as a pure crop or mixed with a variety of other perennial crops, or again in rotation with paddy, sugarcane and other agricultural crops.

PRODUCTION AND ACREAGE

According to an estimate by the Agricultural Marketing Adviser to the Government of India, bananas occupy 404,550 acres in India, representing roughly a little over 25 per cent. of the area under all fruits. It therefore ranks next in importance only to the mango in respect of the area devoted to it. Considering the distribution of bananas it is found that with a total area of 136,455 acres in Madras, 47,504 acres in Travancore, 21,030 acres in Mysore, over 2,500 acres in Cochin and an undetermined area in Coorg, totalling to over 210,000 acres in South India in 1940-'41, the region claims the largest area amounting to over 53.0 per cent. of the total area in the country. Although the annual banana production of India as a whole is estimated at 110 million maunds, the average annual export of fruits during the three years (1937-'38 to 1939-'40) was only 12,000 maunds.

To some extent the banana production varies from year to year, it having claimed over 154,000 acres in 1934-'35 and only about 136,000 from 1939 to 1941 and about 130,000 acres in 1942-'43 in the presidency of Madras. From the figures relating to the acreage in 1934-'35, it is found that, Malabar with over 52,000 acres shared roughly one-third of the banana area in the province of Madras. Madura, Tanjore and Trichinopoly districts ranked next with about 18,000, 11,600 and 10,000 acres respectively. Tinnevelly, Coimbatore, Salem, East and West Godavary followed next with an approximate acreage of 8,000, 6,400, 6,800 and 5,700 acres respectively. Roughly 3,900 acres were devoted to the fruit in Vizag; 2,400 acres in Ramnad; 3,600 acres in South Kanara; 2,400 acres in Chingleput; 2,000 acres in South Arcot and 1,900 acres in North Arcot, with other districts claiming less than 1,200 acres under the crop. Taking the varieties into consideration, it is noted that roughly Poovan accounted for an annual production of 741,000 tons from an area of 74,000 acres in 1941, and was thus the leading commercial variety. Nendran and Monthan were the next in importance, accounting for about 90,000 tons each per annum from an area about 14,900 and 11,300 acres respectively. Kunnan with 49,000 tons from an area of about 8,200 acres, Mauritius with 38,000 tons from 4,100 acres, Rastali with 33,000 tons from 4,200 acres, Hill bananas with about 16,000 tons from 6,500 acres are the next in commercial importance, with Pacha Nadans and Chakkarkeli and other miscellaneous varieties following. The total production in 1941 was about 1,133,000 tons, of which roughly 910,000 tons were ordinarily exported by rail in pre-war years from the producing centres to outside districts and provinces. Trichinopoly with about 529,000 tons, East and West Godavary with about 100,000 tons, Madura with about 80,000 tons and Salem with about 83,000 tons were the main exporting centres. The exports by rail outside the province ranged in pre-war years from roughly 80 to 90,000 railway maunds mainly from Cauvery area to Mysore State and from 60,000 to 120,000 railway maunds from Godavary area to Nizam's State, Orissa and North India.

Published figures relating to other areas in South India show that Mysore accounts for an annual production of about 736,000 maunds, Coorg for 95,000 maunds, Cochin State for 519,000 maunds and Travancore for 2,328,000 maunds in 1940-'41, while Madras led in that year with a production of 31,315,000 maunds ranking next to Bengal.

It seems that the South Indian banana production is comparable in size to that from any other banana producing country of the world. Notwithstanding this, it has not merited the attention it deserves from international trade as that enjoyed by a country like Jamaica, so that as against an average annual export of the value of £2,000,000 from Jamaica, there is but an insignificant quantity of fruit exported overseas from South India. The example of a small island like Jamaica with an area of only about 4,200 square miles assuming the leadership in banana world trade with an export of over 20 million bunches per year overseas to form nearly more than half of the total exports of that island, should indicate in some measure the scope for the extension and improvement in the South Indian banana industry and export trade, with all its undoubted advantages as high yield, low cost of production, relative freedom from any serious pests or diseases, high fruit quality and long coast line.

Climate:—The banana grows up to an elevation of about 5,500 feet. Being a moist, heat-loving tropical plant, it does not relish either a severe winter and frost-occurring situations or arid and unirrigated regions. In the presidency of Madras, Anantapur is the least suitable district for bananas, because of the absence there of irrigation on a large scale and of the prolonged dry atmospheric conditions caused by scant precipitations. On the other hand, even a relatively higher altitude as that enjoyed by Wynad and slopes of the Nilgiris and Lower Palnis are found to suit banana production, favoured as they are by relatively higher rainfall and atmospheric humidity. Since flourishing banana plantations are found in the warmest and driest tracts of South India such as those in Rayalaseema, Guntur and Kistna, provided the groves are amply supplied with moisture from tanks, wells or channels, it seems that moisture is the most important limiting factor, even more important than atmospheric humidity and temperatures. Freedom from frost is, however, a pre-requisite for the success of banana culture on a commercial scale. Ground frosts are experienced in South India only over elevations exceeding about 5,000 feet, and till this limit the banana finds itself at home, if the above-stated conditions are fulfilled. Within the vast range of climatic conditions available for the crop, it is found, however, that there is a great range of tolerance between the varieties to environmental conditions. For instance, Nendran types are found best under West Coast conditions, while the Sirumalai and Virupakshi varieties are only able to produce quality fruits in the higher slopes of Lower Palnis. The deterioration in the flavour of the fruit has been noticed with Chakrakeli too when grown outside the Northern Circars. The importance of zoning the varieties so as to limit their production to the tracts most suitable to each is as important in banana production as in any other fruit.

Soils:—Being a gross surface feeding crop, the banana prefers a rich soil with ample moisture and plant food elements but with good drainage at the roots. It is one of the very few fruits which can grow in wet paddy lands and yield heavy crops, provided some precaution is taken to ensure drainage. Shallow soils, which are generally deemed unfit for efficient production of perennial tree fruits need not be a disqualification for the banana, so long it is rich and is uniform up to about three feet depth from the surface. In regard to texture of soils, the banana is more adaptable than most fruits, since flourishing plantations are found on light sandy or gravelly soils as well as on stiff clays. Only the very sandy coastal soils are found unsuitable, as in such media the water-holding power is extremely low and both moisture and plant food are liable to be leached off spreading beyond the root zone. Between the open-textured loams and close-textured clay soils, the suitability is largely influenced by the fertility of soil, the choice being in favour of that which is more favourably situated in respect of irrigation facilities, besides being better supplied with plant food elements including organic matter or humus. Observations at Coimbatore in one season seemed to show, however, that banana yields are heavier in irrigated plantations on garden lands than in wet lands, with also a slightly earlier production of inflorescence in most varieties in the former area. In Tanjore where the river Cauvery ramifies greatly to produce numerous silt-deposited *padugai* stretches near Aduthurai, the banana grows much better than in wet lands, and crops satisfactorily even for a hundred years or more. On the other hand, in Trichinopoly district wet lands are preferred for the banana, as they are easier to irrigate than garden lands.

CLASSIFICATION AND VARIETIES

Although the banana has been an important cultivated fruit from time immemorial its specific and varietal status have never been well defined so as to be universally acceptable. The main reason for the existing confusion in the taxonomy of bananas appears to be partly due to the lack of accurate and complete descriptions of all the varieties and partly to the adoption of different approaches and standards to the study of nomenclature and classification by the workers. The present chaotic conditions have been deplored by eminent workers on the ground that such taxonomic confusion causes a serious hindrance to banana research causing unnecessary wastage of efforts and money.

According to the classification of Linnaeus, cultivated varieties of bananas appear under two distinct species, *viz., Musa sapientum* and *Musa paradisiaca.* Cheesman in 1934 has explained how the above classification cannot hold good on the ground that, the basis of distinction adopted by Linnaeus, *viz.,* the deciduous or persistent nature of the male flowers does not apply to some varieties, and that the character of the persistent or deciduous nature of the male or functionally staminate flowers is a very variable one. Supporting this view of Cheesman, Venkataramani has pointed out how some plants of Adakka Kunnan were observed by him to have some clusters of the dried male flowers persistent on the axis, while in some others the axis was purely naked. There is also no provision in such a classification based on the nature of the male flowers to group types which do not at all produce any staminate flowers such as the Moongil variety of South India, which according to Venkataramani does not at all produce any male or staminate flowers, and the fruiting axis ends blindly after the formation of one or a few hands of fruits. Others have placed the dwarf banana under a distinct species *Musa Cavendishii,* but Cheesman has shown that at least one tall banana variety appeared so closely allied to the dwarf varieties that the original definition of the species becomes inapplicable. Other systems of classification have also been suggested by different workers with even less justification. On the score of wider and longer usage, the specific name of *Musa sapientum* may be taken as the most appropriate, till more is known of the banana taxonomy. The arbitrary distinction between banana and plantain is also now not accepted, the former name being almost universally used as appropriate for all cultivated and edible varieties of *Musa.*

It is clear that classification of bananas can only follow an accurate and complete descriptive study of varieties. Jacob has done much in this field, though his descriptions are only limited to certain characters. Characters of importance to the growers such as leaf and sucker production which are undoubtedly very variable according to many factors of cultivation are not usually found in recorded banana descriptions, even though varieties differ greatly between themselves in respect of these characters. Venkataramani has, therefore, taken note of such economic characters in his study of some Indian bananas.

The number of so-called varieties found in South India is almost a legion, and many of these are mere synonyms. On the basis of a survey in South India, Jacob has been able to record descriptions of almost every cultivated variety to a certain extent. Venkataramani followed with complete descriptions of some varieties which are largely grown in South India for culinary purposes. On the basis of these and some observations recorded by the Fruit Section of the Madras Agricultural Department, the following brief account of some of the important South Indian varieties is presented.

TABLE VARIETIES.

1. POOVAN—(syn. MYSORE, PALEYANGODAN, KARPURA CHAKRAKELI and LAL VALECHI of Bombay):—This is the leading commercial variety of South India, claiming roughly 20,000 acres in Malabar, 8,000 acres each in Tanjore and in Trichinopoly, 6,500 acres in Madura, 6,500 acres in East and West Godavary and 3,700 acres in Tinnevelly. It is popular chiefly as a dessert fruit, though it can also be used for culinary purposes. The pseudo-stems are 10 to 17 feet high, the bunches are closely packed, fruits are terete with a distinct apex; colour of fruit is yellow; quality good. Leaves are

largely used as substitutes for dining plates. The variety is a heavy yielder normally with 10 to 14 hands, but going up to 18 hands

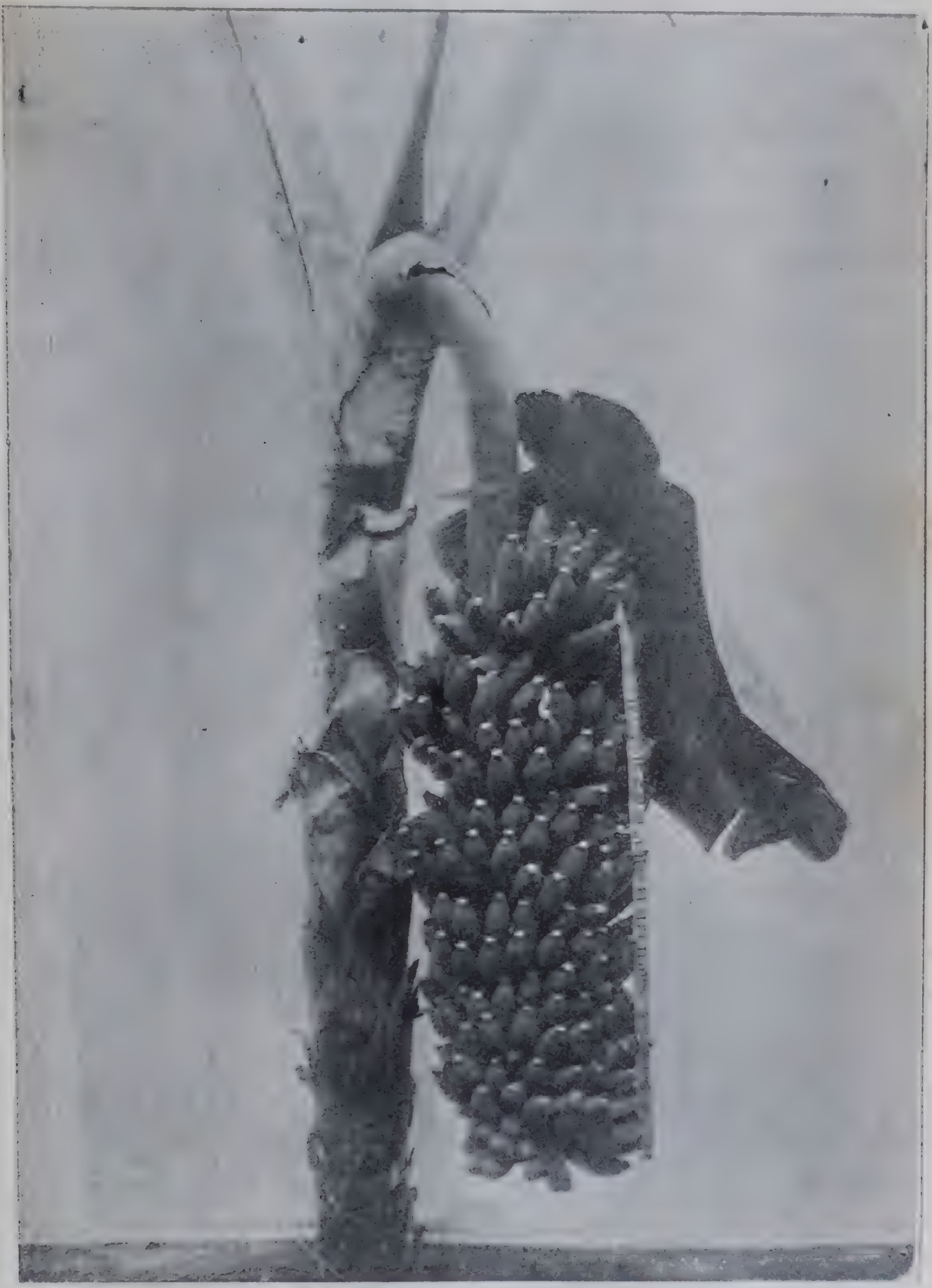

Fig. 68. Poovan. (*Courtesy of the Botany Section, Coimbatore*).

and over 300 fingers, each bunch weighing up to about 60 lbs. Being a hardy variety it grows from sea level up to 5,500 feet. The fruits are available all through the year.

2. KUNNAN:—This is also a popular group of varieties of the West Coast with about 7,000 acres under it in Malabar. Kunnan, Adakka Kunnan, Then Kunnan and Thattilla Kunnan are some of the important varieties, brief descriptions of which are given below.

(1) KUNNAN:—Pseudo-stem slender, about 9 feet high, light green; leaf narrow and erect; bunch matures in about 16 months, bunch small, compact and pendulous; hands compact, about 10 in number with 12 fingers to a hand; sterile axis naked and pendulous; fruit small, about 4.5" long and 4.5" in girth at the middle, slightly ridged, apex prominent and pointed, skin shiny, thin and bright yellow when ripe, easily peels off from pulp; pulp cream-coloured, firm, sweet with an aroma, keeps well; used for table and also for culinary purposes. Fruits enjoy a reputation as an invalid food; the flour prepared out of it being also fancied by some as an infant food.

(2) ADAKKA KUNNAN—(syn. VENITTU KURA) :—Plant characters as for Kunnan, fruit spindle-shaped and plumpy at the middle ; pseudo-stem with an ashy and light green bloom, dull yellow when ripe and peels with some difficulty ; pulp as in Kunnan; raw fruits used for culinary purpose, flour of this too is said to be good as infant food. The fruit is very small resembling the shape of an arecanut, from which it derives the name.

(3) THATILLA KUNNAN :—This produces only pistillate flowers, and no male flowers are observed. Bunch is heavy and compact. Fruits are unequally five-sided and slightly flat on sides. Apex is long and tapering. Pulp is dry and white, and very sweet. It is considered to be one of the choice dessert varieties resembling Then Kunnan in many respects, except in having only female flowers.

(4) THEN KUNNAN:—This is a medium-sized plant with very erect petioles, with reddish tinge. The pseudo-stem too has similar tinge. Bunches are medium in size with about 15 hands and 150 fingers, weighing about 25 lbs. Fruit is about four to five inches long with prominent ridges, long pedicel and prominent apex. Pulp is pure white and dry. It is classed as a delicious variety with good keeping quality.

3. HILL BANANAS:—These are grown largely in the hill slopes in Madura district, where about 6,700 acres are devoted to them. They form some of the best table fruits, with an excellent flavour

and taste and good keeping quality, due to which they are much in demand in urban areas. They deteriorate in eating qualities when grown on the plains, and seem to be at their best on altitudes ranging from 2,000 to 5,000 feet in South India. Under this group there are two well-known varieties, descriptions of which follow.

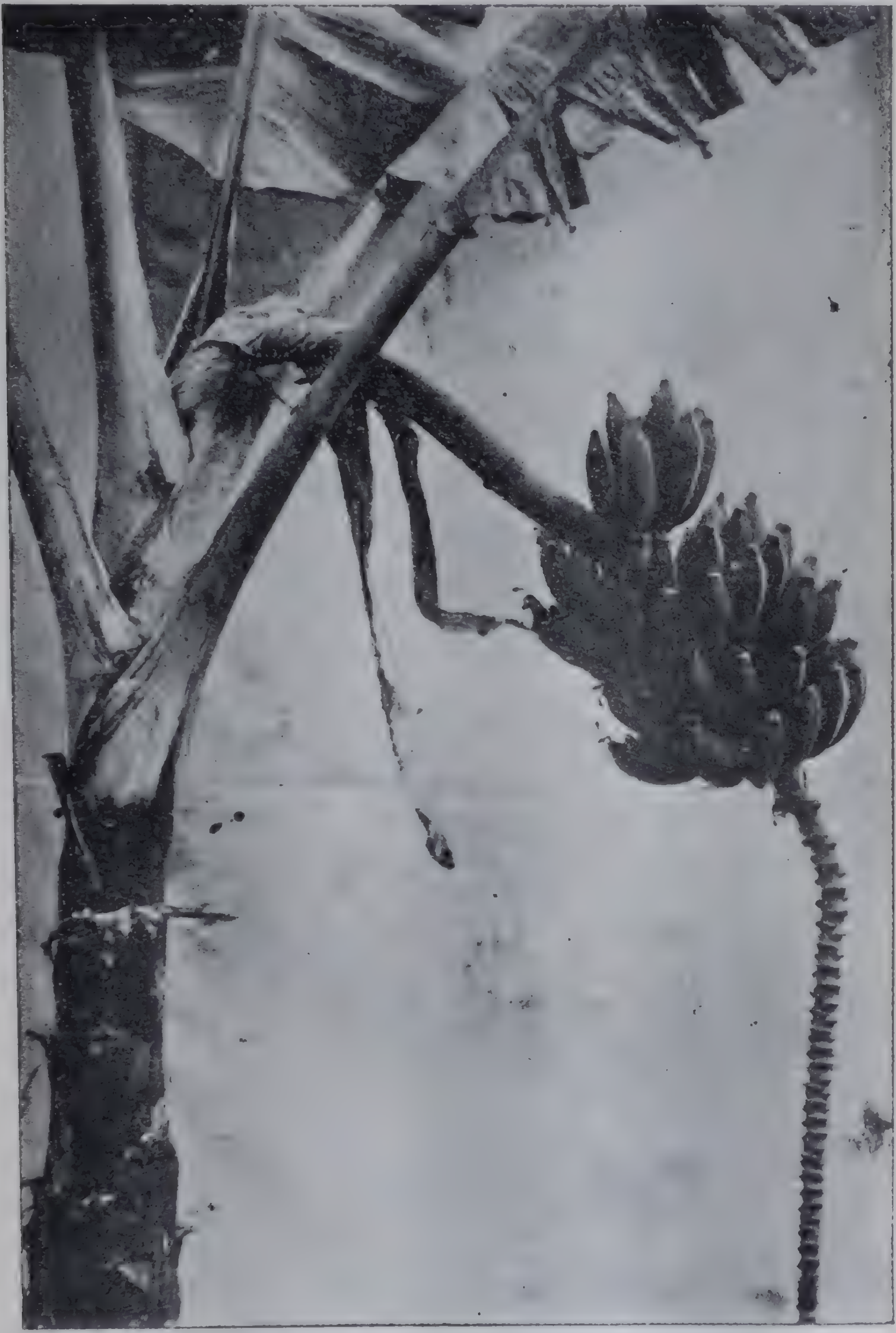

Fig. 69. Sirumalai.
(*Courtesy of the Botany Section, Coimbatore*).

(1) Sirumalai (syn. Mala Vazhai):—The name is derived from the Sirumalai Hills of Madura district where it is grown between 2,000 to 2,500 feet elevations. Fruits are distinctly angular with a distinct apex and a dusty yellow skin. Pulp is juicy and of high flavour and taste. Fruits are liable to drop off from the pedicels. About 100 fruits per bunch weighing about 20 lbs. is the normal yield.

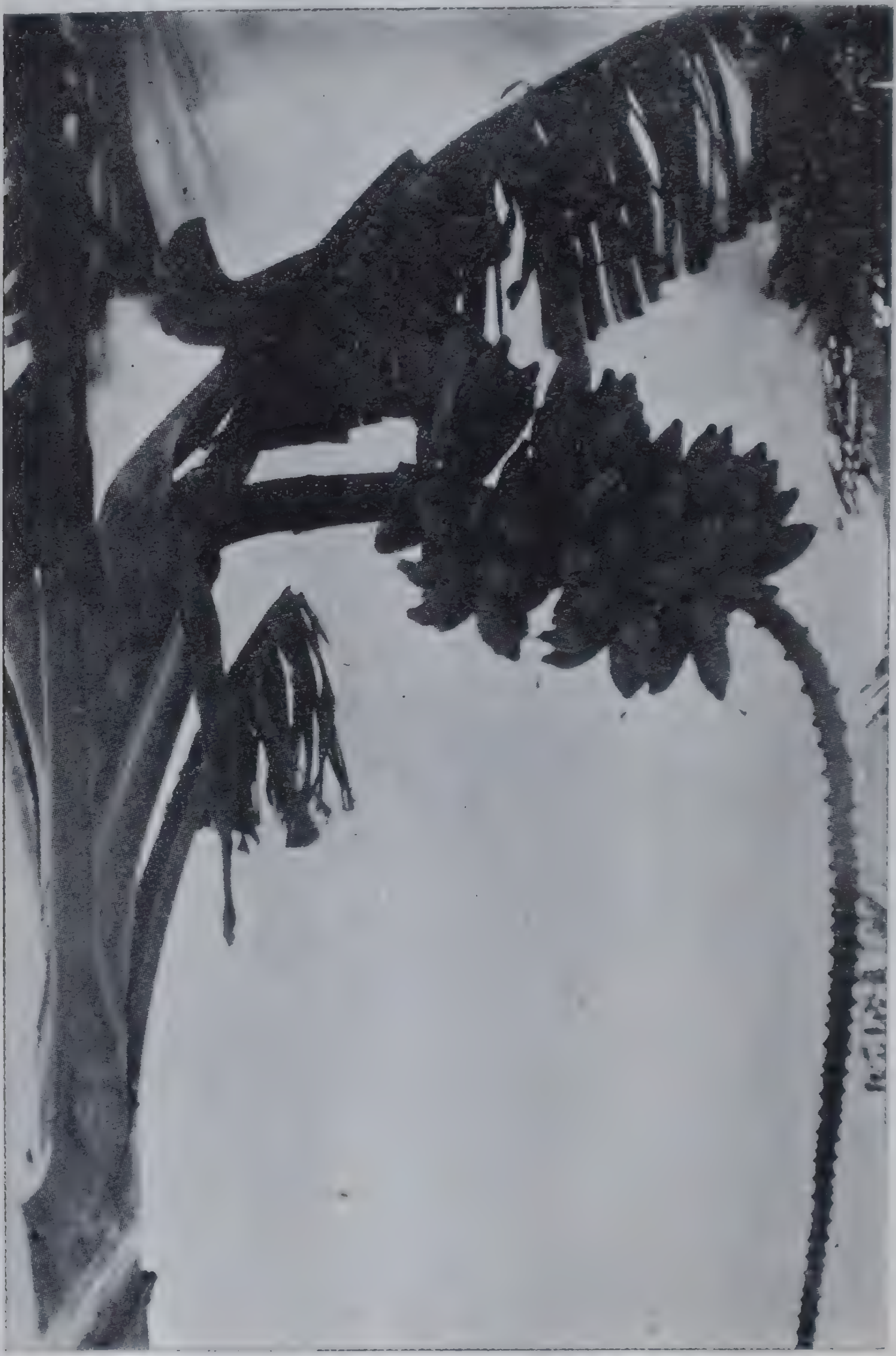

Fig. 70. Virupakshi. (*Courtesy of the Botany Section, Coimbatore*).

(2) Virupakshi:—This is similar to Sirumalai but grown on slightly higher elevations between 3,500 feet to 5,000 feet. The fruits, however, are not juicy as Sirumalai, though equally reputed for quality. The famous conserve *Panchamritam* of the Palni temple is made from the fruits of this variety. The ripe fruits keep longer than the Sirumalai.

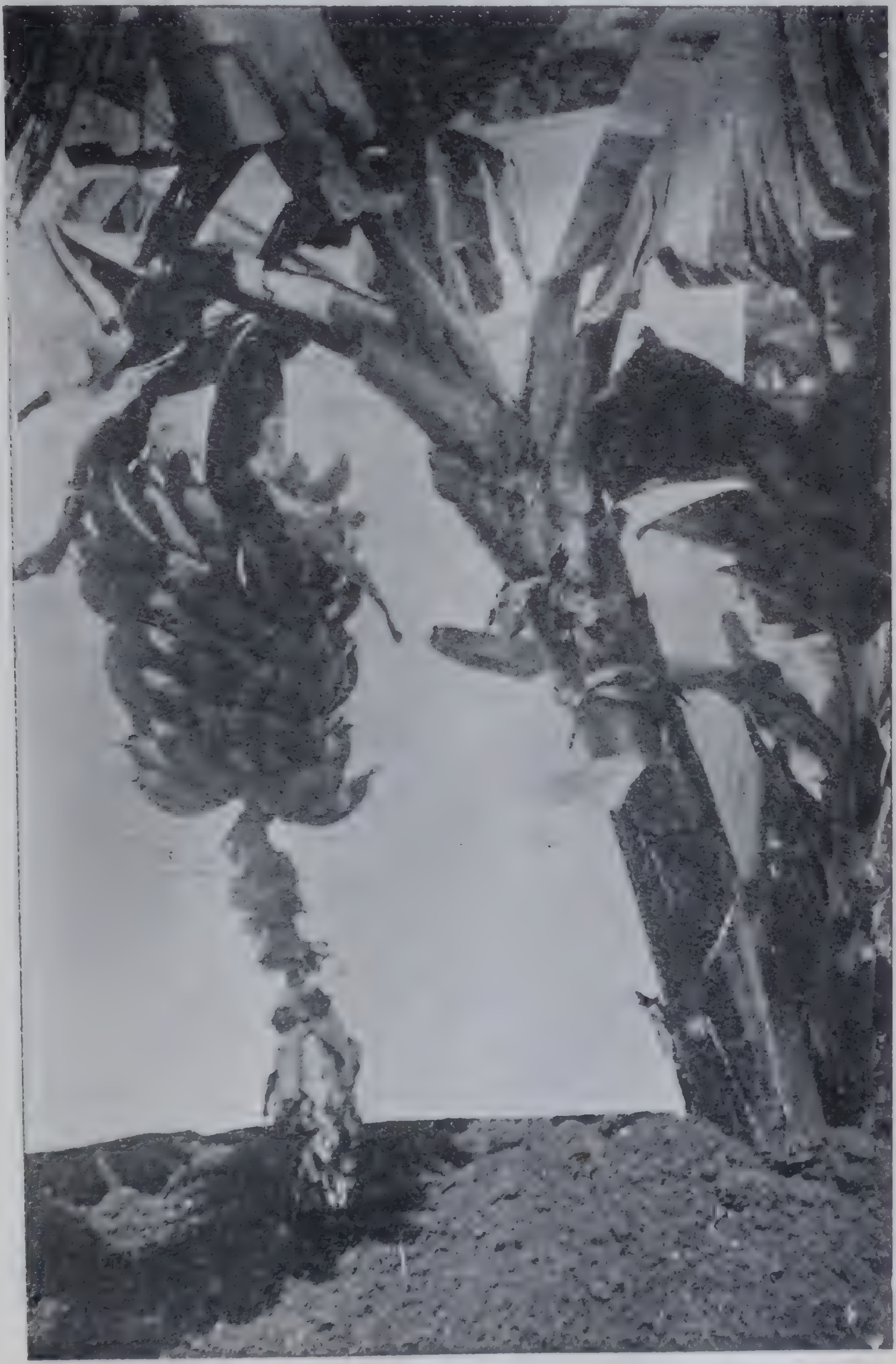

Fig. 71. Vamankeli.

(Courtesy of the Botany Section, Coimbatore).

4. MAURITIUS—(syn. VAMANAKELI, BASRAI of Bombay, CAVENDISH, GOVERNOR, CHINA BANANA):—This is the dwarf banana that is popular in many parts of South India, claiming a total area of over 1,000 acres each in Tanjore, South Arcot and Cuddapah It is the shortest stemmed banana under cultivation and is very heavy yielding. Fruits are large, terete with blunt apex, and with very

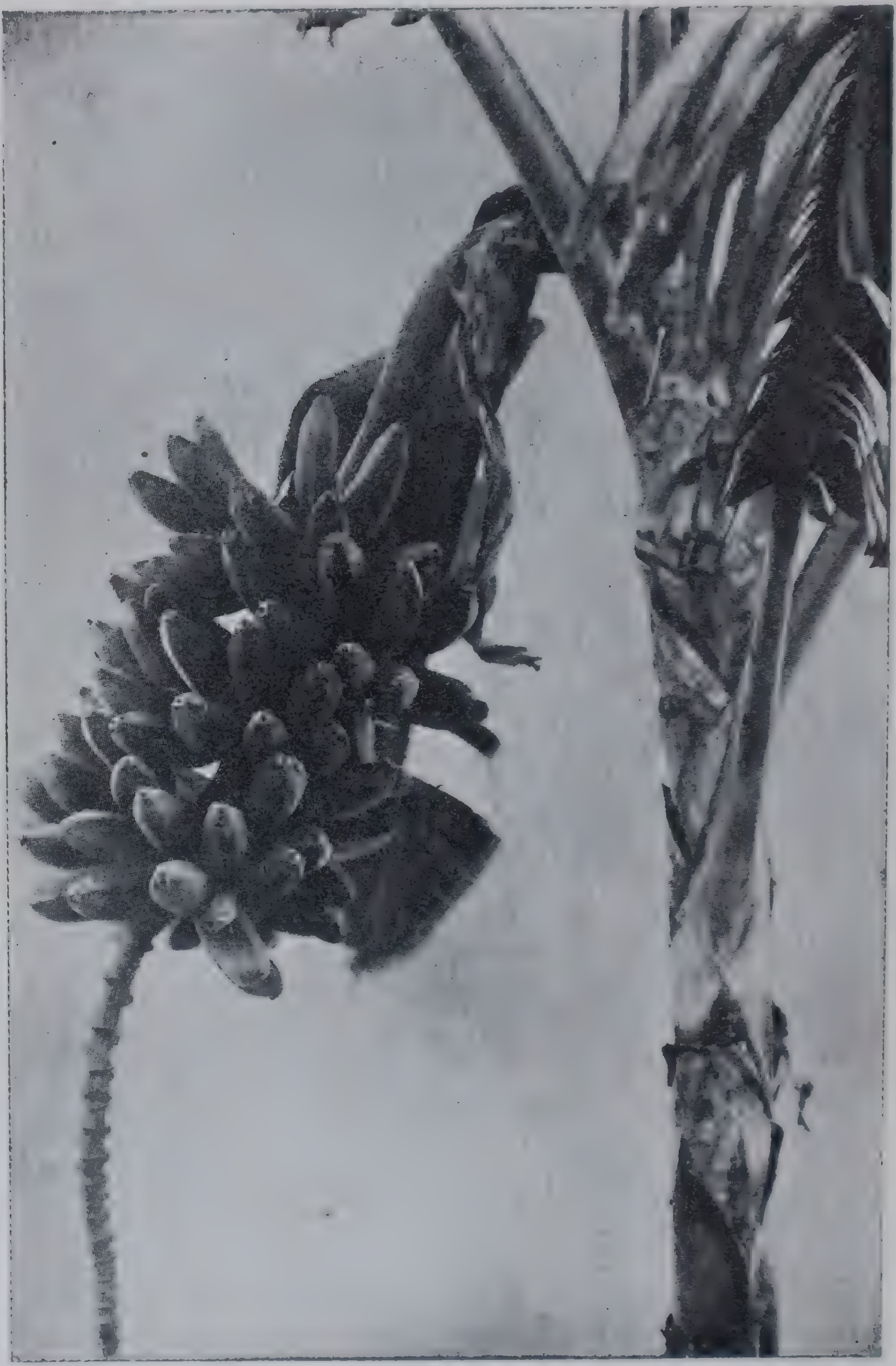

Fig. 72. Pacha Nadan.
(*Courtesy of the Botany Section, Coimbatore*).

sweet and aromatic pulp. The skin colour may be green or dull yellow. Giant Governor resembles the Mauritius in all respects, excepting in having taller pseudo-stems while a very dwarf type

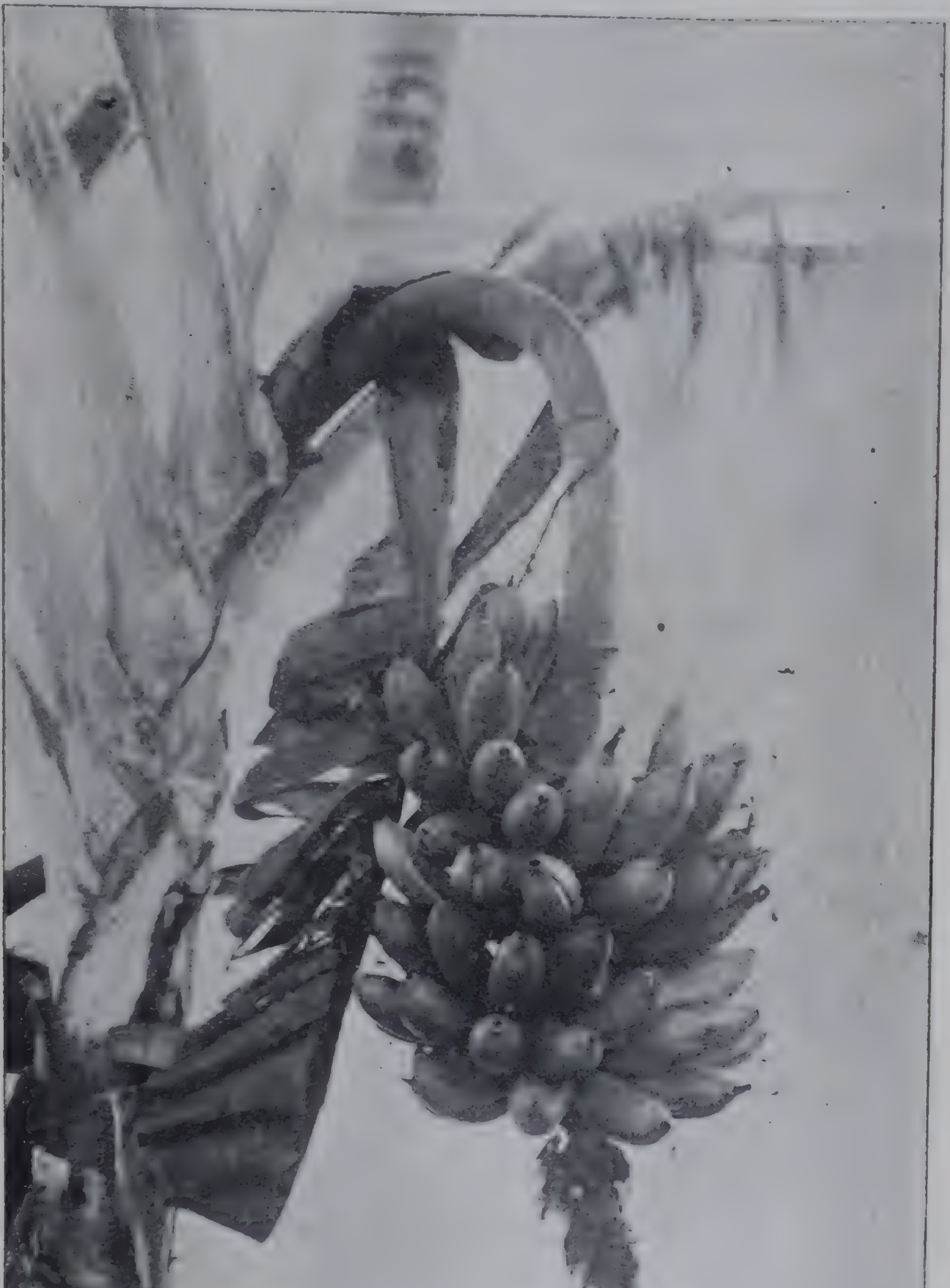

Fig. 73. Rastali.
(*Courtesy of the Botany Section, Coimbatore*).

goes by the name of Cavendish in parts of Mysore. The bunches of Mauritius are heavy, weighing as much as 60 lbs., with about 150 fruits per bunch. The variety is specially favoured in localities subject to high wind damage. The fruits are greatly in demand in Central and North Indian markets for table purposes, but are only gradually gaining popularity in Madras markets and elsewhere in South India.

5. PACHA NADAN:—This variety is popularly grown in Tinnevelly, Ramnad and Coimbatore districts, with an area of about 1,000 acres in each. The pseudo-stems are about 10 feet tall, and bunches are fairly heavy, and compact, with 6 to 12 hands and 12 fruits per hand. Fruits are angular, irregularly five-sided, each about 5.5" long and 4.5" in girth at the middle, with thick rind and semi-juicy pulp. Fruits keep well and are classed among the fairly good table fruits. The yield is about 80 to 100 fruits per bunch, each about 5.5" long and 4.5" in girth at the middle, with thick rind for culinary purposes. Skin is greenish yellow and peels off easily; pulp is firm, whitish and rather saltish. The variety is named differently in Southern districts and has a medium-sized pseudo-stem with a flower head obovate in shape. The variety Kali looks similar to Pacha Nadan, but has a distinct fruit apex and the flower head is more elongated and obovate, with fruits smaller in size.

6. RASTALI:—This is one of the very good table varieties grown on over 1,000 acres each in Salem and Malabar and about 500 acres each in Tanjore and Trichinopoly districts. In dry areas the fruits have a tendency to be under-sized but free of any lumps in flesh and superior in taste. The pseudo-stems are about 10 feet high and the bunches are medium-sized. The fruits are terete and taper to an apex. They tend to drop off easily from the pedicels when fully ripe, though they have a good keeping quality. This is a variety that withstands high winds fairly well though not to the same extent as Mauritius. In taste the fruits appear dry and flowery, but the pulp develops lumpy masses in heavy manured soils.

7. CHAKRAKELI—(syn. TELLA CHAKRAKELI, RAJABALE):—About 1,000 acres are planted to this variety in Northern Circars, where it is highly esteemed as the most prized table fruit. The plant is elegant but takes about 18 months to mature fruits. Fruits are rich in flavour and taste. The pseudo-stem is about nine feet high; bunches are loosely packed and medium-sized. Fruits are terete having a distinct apex. Skin is yellow when ripe, but with

its stigmatic end remaining green. Pulp is soft and melting. The pedicels are strong and have to be cut even when fruits are ripe.

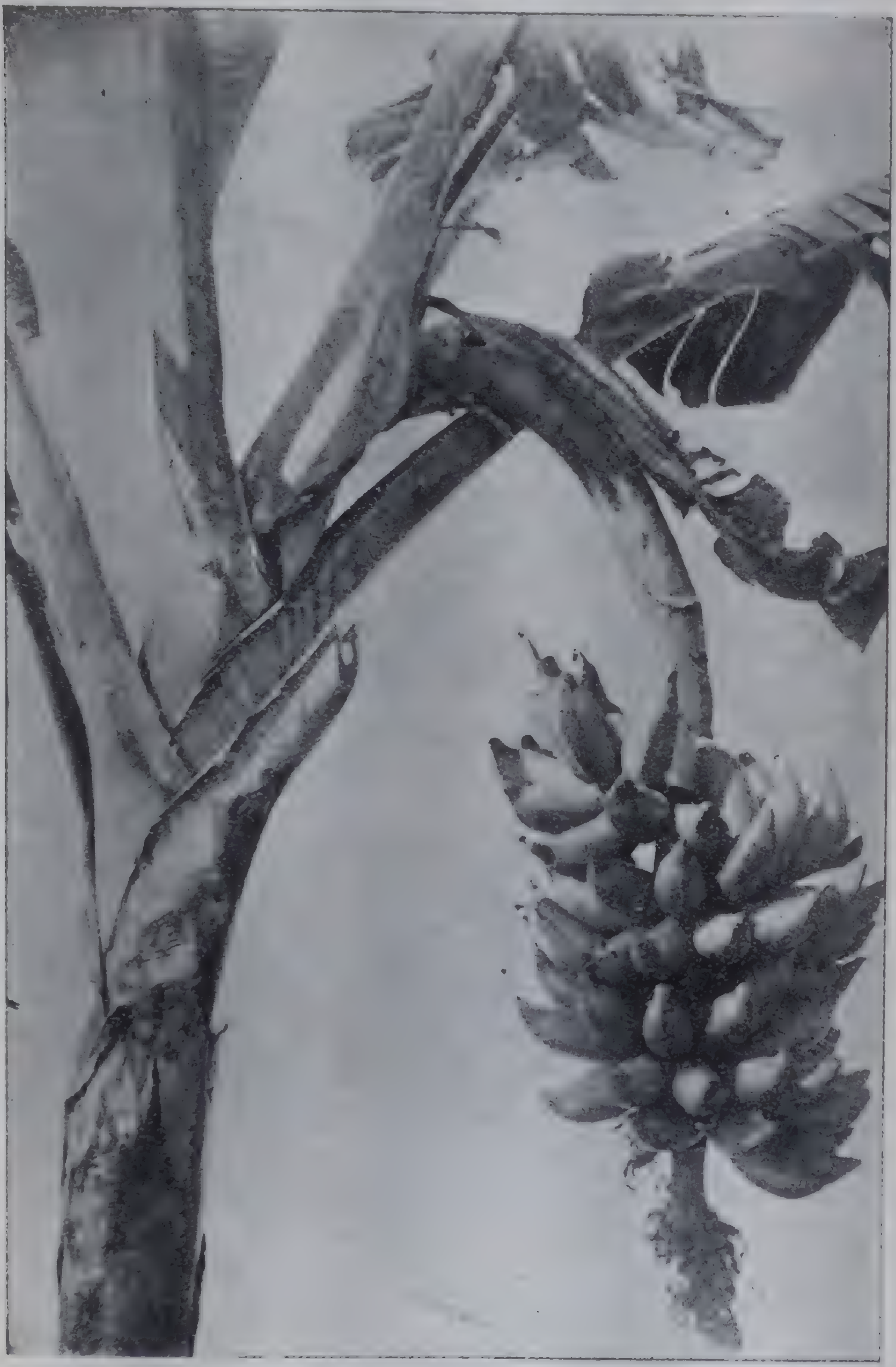

Fig. 74. Chakrakeli.
(*Courtesy of the Botany Section, Coimbatore*).

8. Gros Michel:—This is the famous commercial variety of the West Indies, also called as Claret. It is only grown in a few gardens and has not yet shown its appeal to spread in commercial plantations of South India. It has a tall and elegant pseudo-stem,

which yields bunches weighing about 40 lbs. each and containing 10 hands and 120 fruits roughly. The axis is naked, stiff and semi-erect, and the fruit resembles Mauritius but is indistinctly five-sided. Taste is sweet with aroma; keeping quality good.

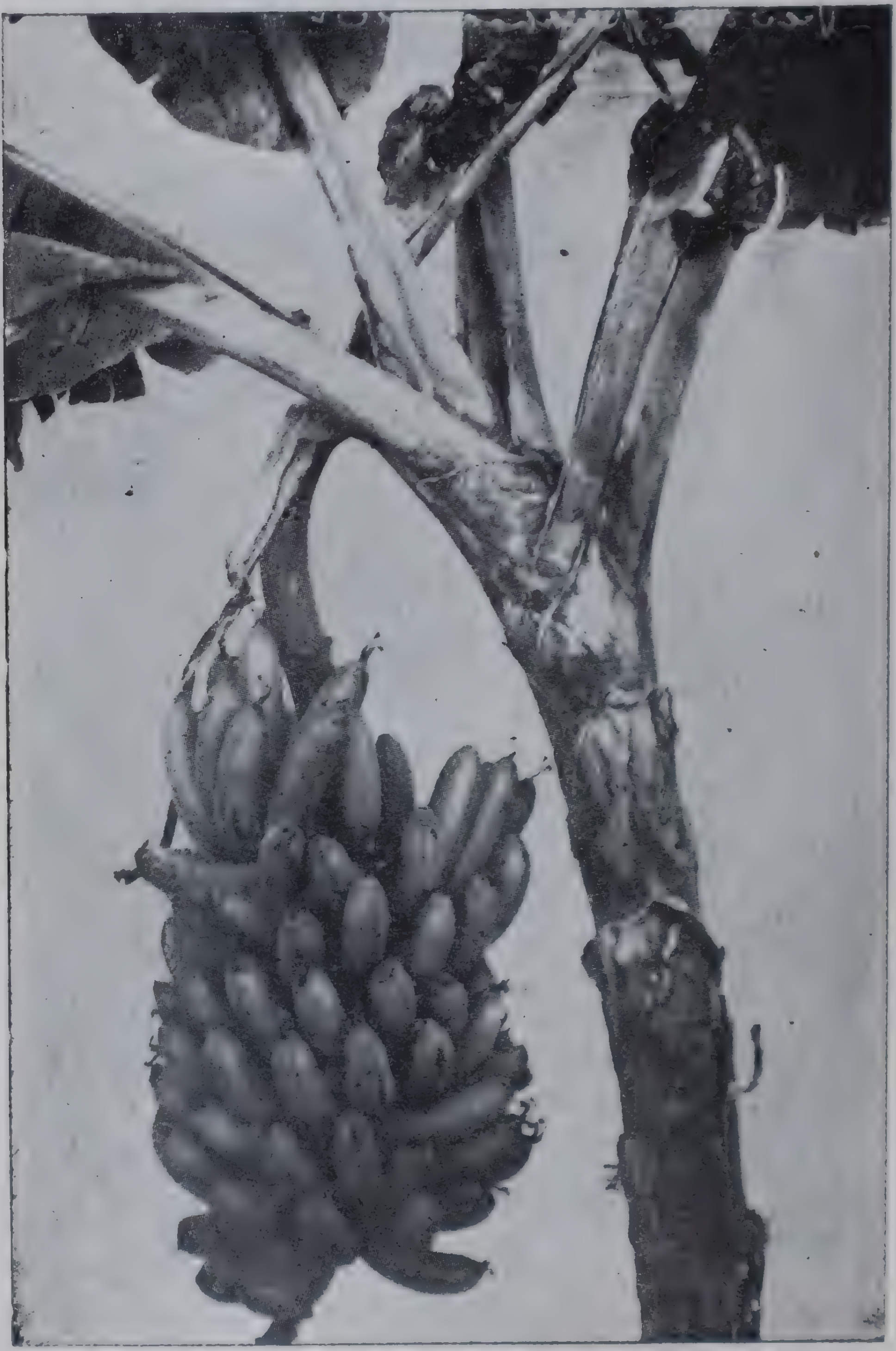

Fig. 75. Pedda Pacha Arati.
(*Courtesy of the Botany Section, Coimbatore*).

9. Ney Poovan :—This is a thin skinned table fruit of th West Coast, with white and dry pulp of good taste and keeping qua

lity. It is terete with a distinct apex. It is similar to the Safed Valechi of Bombay presidency. The pseudo-stem is elegant and is about 10 to 13 feet high; bunches heavy; fruits closely set, terete and tapering to a distinct apex. · A bunch normally weighs about 30 lbs. and contains 15 hands and 200 fingers.

10. MATTAI:—It is said to be a commercial variety of some importance in Southern Travancore. Its fruits are juicy and sweet with good flavour. The pseudo-stem is about seven feet high, bunches compact; and the apex of the fruit long, about 1½" sometimes.

11. CHENKADALI:—This is a very long duration variety taking about 18 months for the harvest of the bunch. Fruits are used for table purposes and have a good flavour and taste. The pseudo-stems are about 14 feet high, bunches are closely packed and medium heavy. Fruits are terete with a distinct apex. The skin colour is red on ripening.

12. PEDDA PACHA ARATI:—This resembles Mauritius, except that the pseudo-stems are slightly taller and thinner, and the naked axis is semi-erect. It is also a heavy yielder, each bunch weighing about 45 lbs. with about 10 hands and 120 fingers. It is mostly found in parts of Kurnool.

13. KAPUR:—A variety confined to parts of South Kanara mainly, it is a heavy yielder with juicy and good flavoured fruits. Pseudo-stems are very tall and robust with greenish stem. Fruit is about nine inches long and is distinctly sided.

14. KADALI:—This is a West Coast variety. The plant is delicate with relatively thin pseudo-stem. Bunch has seven to eight hands, bearing up to 100 fingers, and weighing about 18 lbs. Fruit is small, terete, juicy and thin skinned. The main axis is semi-stiff. The fruit is largely used for offerings in temples.

15. NALLA CHAKRAKELI:—A variety popular only in the Circars with dark green pseudo-stems. Fruits are plumpy with indistinct sides and very short pedicels. Skin of immature fruits is dark green as compared to light green colour in fruits of Tella Chakrakeli. Fruits of Nalla Chakrakeli are distinctly poorer in quality than Tella Chakrakeli, though the former is a heavier yielder with eight to ten hands and about 120 fingers, weighing in all about 35 lbs.

16. NAMARAI:—A very tiny plant grown on the Lower Palnis along with Virupakshi. Fruit is small with a wavy surface, and is slightly acidic and juicy. Bunch is small with five to six hands only weighing about five lbs. and with about 100 fruits.

17. KARIM KADALI:—A West Coast variety and a heavy yielder with about six to eight hands, 100 fingers and weighing about 35 lbs. The pseudo-stem is of medium height and is dark red coloured with dark blotches. Fruit is long up to nine inches, cylindrical and with a distinct apex. Raw fruits are said to possess medicinal properties, being useful in curing dysentery.

CULINARY VARIETIES:—

1. NENDRAN:—This is a group name applied to some closely allied varieties grown over an area of about 4,000 acres in Malabar and 1,000 acres in South Kanara. As a 'filler' in Poovan plantations, it is gaining some popularity in Trichy district recently. Travancore and Cochin States are also important producing centres of these varieties. Nana Nendran is the most important variety in this group and is said to resemble the Pisang Talon or Tandok of Malaya. Nendravazhai, Nendrabale, Thiruvodan, Chengazhikodan and Ethakka are the synonymous in the West Coast. Kali Eththan, Attu Nendran, and Veleththan are other varieties of Nendran found in the West Coast A few other varieties are also believed to come under this group among the varieties grown in the North Malabar. Nayar records Attu Nendran, Nana Nendran, Nedu Nendran, Tiruvodan, Chengaikodan, Myndoli, Kudirvaly and Nendran as the varieties of Nendran group cultivated in Malabar successfully on the porous, well-drained laterite soils, and both in wet and garden lands. Fruits of both in ripe and raw state are available in Malabar all the year round Nendrans produce fruits which are larger in size than other cultivated bananas. The raw fruit is popular for culinary use by itself o mixed with other vegetables. The pulp is fried in oil and preserved after salting or sweetening in jaggery syrup. Ripe fruits are consumed fresh or after cooking in steam or baking on fire. Jams *halwa*, fruit salads, and conserves are other uses to which Nendran have been put. With their hard pulp and thick skin, Nendrans ar able to keep long—up to 15 days after ripening, and have th additional advantage of not falling off from the bunch. The plants however, are subject to damage by high winds. Brief descriptio of four well-known varieties follow.

(1) NANA NENDRAN:—Pseudo-stem about 10 feet high; bunch not compact; number of hands four or five with about six to nine fruits per hand; fruit almost at right angles to the main axis; male flowers and bracts persistent; fruit irregularly five-sided, 11 to 12" long and about five inches in girth; apex short but distinct; skin thick, tough and golden yellow coloured, peeling off with difficulty from

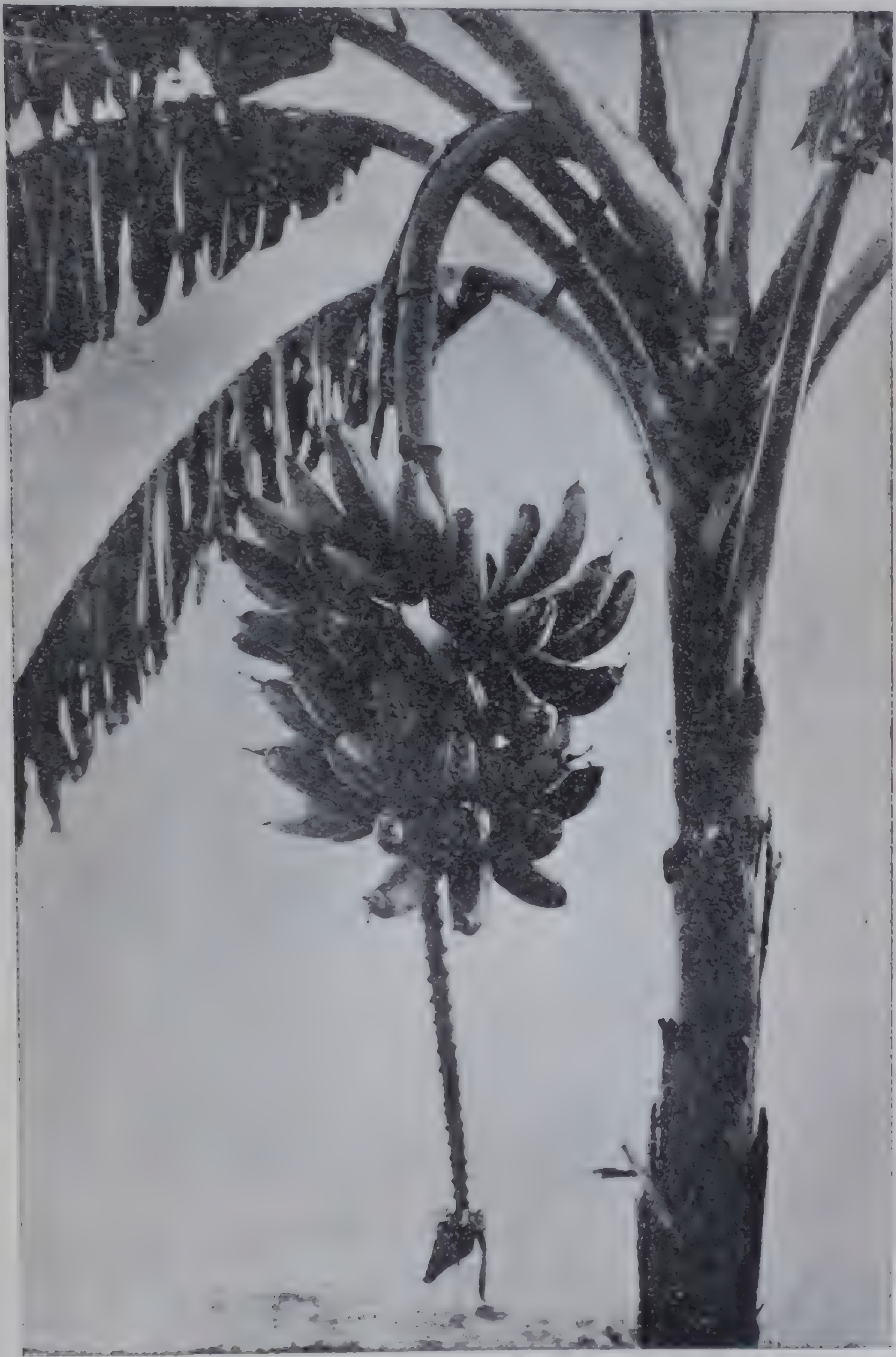

Fig. 76. Monthan.
(*Courtesy of the Botany Section, Coimbatore*).

the pulp; pulp firm, slightly pink in colour, with quality medium as a dessert fruit; margins of leaf petiole and mid-rib coloured pink; fruit matures in about fourteen months from the date of planting.

(2) ATTU NENDRAN:—Pseudo-stem about 11 feet high; bunch drooping and compact with seven to eight hands; fruits long and curved upwards; male flowers and bracts persistent, clothing the axis; fruit about nine inches long and with about 5.5" girth at the middle; irregularly five-sided, apex tapering to a long and pointed beak, skin and pulp as in Nana Nendran. This variety goes by the name of Nendran in parts of Malabar. It matures in about 19 months.

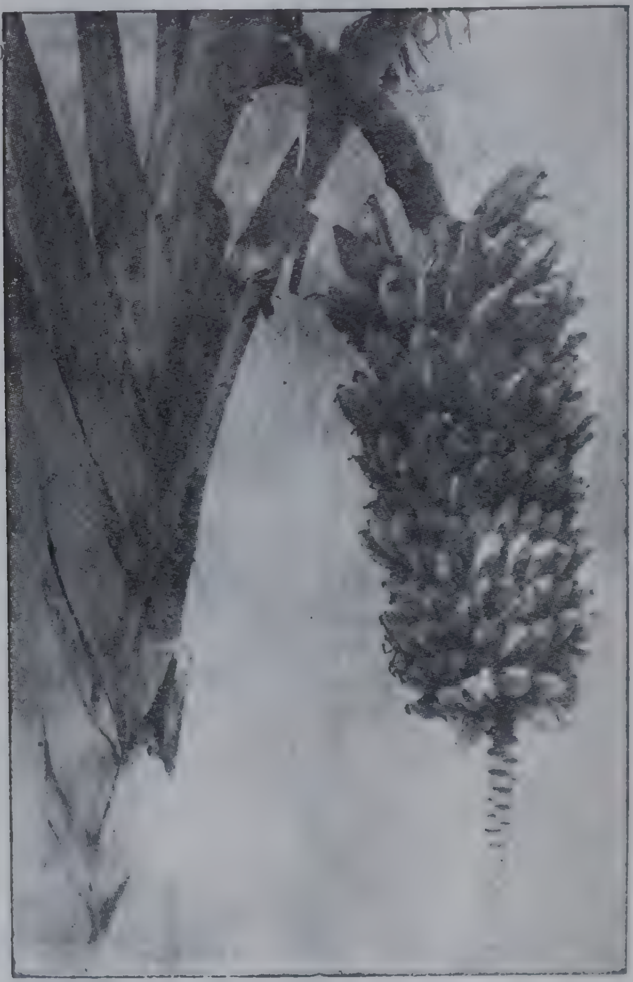

Fig. 77. Pacha Montha Bathees.
(*Courtesy of the Botany Section, Coimbatore*).

(3) MYNDOLI:—This resembles Attu Nendran in plant, fruit and bunch characters, but the hands number about 10, and is classed as a heavy-yielding Nendran.

(4) MOONGIL:—This also resembles Attu Nendran and Myndoli in plant characters. Bunch is semi-erect; hands one or two only, each with about 15 fruits; fruits curved; axis ends blindly.

staminate flowers absent; fruit about 13" long and 6.5" in girth in the middle; pedicel long and slightly twisted, irregularly five-sided; apex with a long pointed beak, skin medium thick, tough and golden yellow. It is a relatively poorer yielder than the Myndoli.

2. MONTHAN—(syn. ERODE MONTHAN, TRICHY MONTHAN etc.):—This is also a primarily culinary variety claiming about 3,000 acres in Malabar, 2,000 acres in Madura, 1,200 acres in Tanjore, 900 acres in Coimbatore and about 800 acres in Trichinopoly. The pseudo-stems are about 12 feet high; suckers well, producing about 16 per plant; bunch loose with five to seven hands, each hand with about 10 fruits; male flowers deciduous and sterile axis naked; fruit about 10" long and six inches in girth at the middle, slightly curved; apex broad with a prominent knob-shaped beak; skin thick and tough, peeling off with some difficulty and straw yellow in colour; pulp firm, cream coloured; taste medium sweet, pasty when ripe, and quality poor as a fresh fruit. Duration about 15 months. Sambrani Monthan is similar to Monthan, except in having an ashy-coated skin.

3. PACHA MONTHA BATHEES:—The plants of this variety resemble those of Monthan. The bunch is compact and the fruits are of various sizes, the first four or five hands being large and the rest small. Hands are numerous. The variety is grown mainly in the Circars.

4. NALLA BONTHA:—This is another culinary variety much in demand in Madras markets and in the northern parts. The plants and bunches resemble Monthan, but the apex of the fruit is not knob-shaped as in Monthan, but is sharp and pointed somewhat.

5. PEY LADEN:—A tall and stout pseudo-stemmed plant, this variety is also a heavy yielder with fruits of medium size, angled and green, with a slight bloom. It is largely used for culinary purposes in Trichinopoly district.

6. NEY MANNAN:—Also a culinary variety but occasionally used for eating as ripe fruit. In the former capacity it is popular in southern parts of Tamilnad. The ripe fruits have little flavour, however.

7. BOOTHI BALE—(BONYA BARE in South Kanara):—This is a West Coast variety also grown in Mysore. The pseudo-stem is tall with angular, ashy-coated fruits which are said to cool the system when consumed. Quality poor both as a table and culinary fruit.

OTHER BANANAS :—

1. KALI :—This variety is said to be found in a wild condition in parts of Coorg, South Kanara and Malabar, being very hardy. The pseudo-stems are about 16 feet long, bunches fairly heavy, fruits unequally five-sided, with a distinct apex. Colou of the skin is yellow or greenish when ripe. Green fruits are use

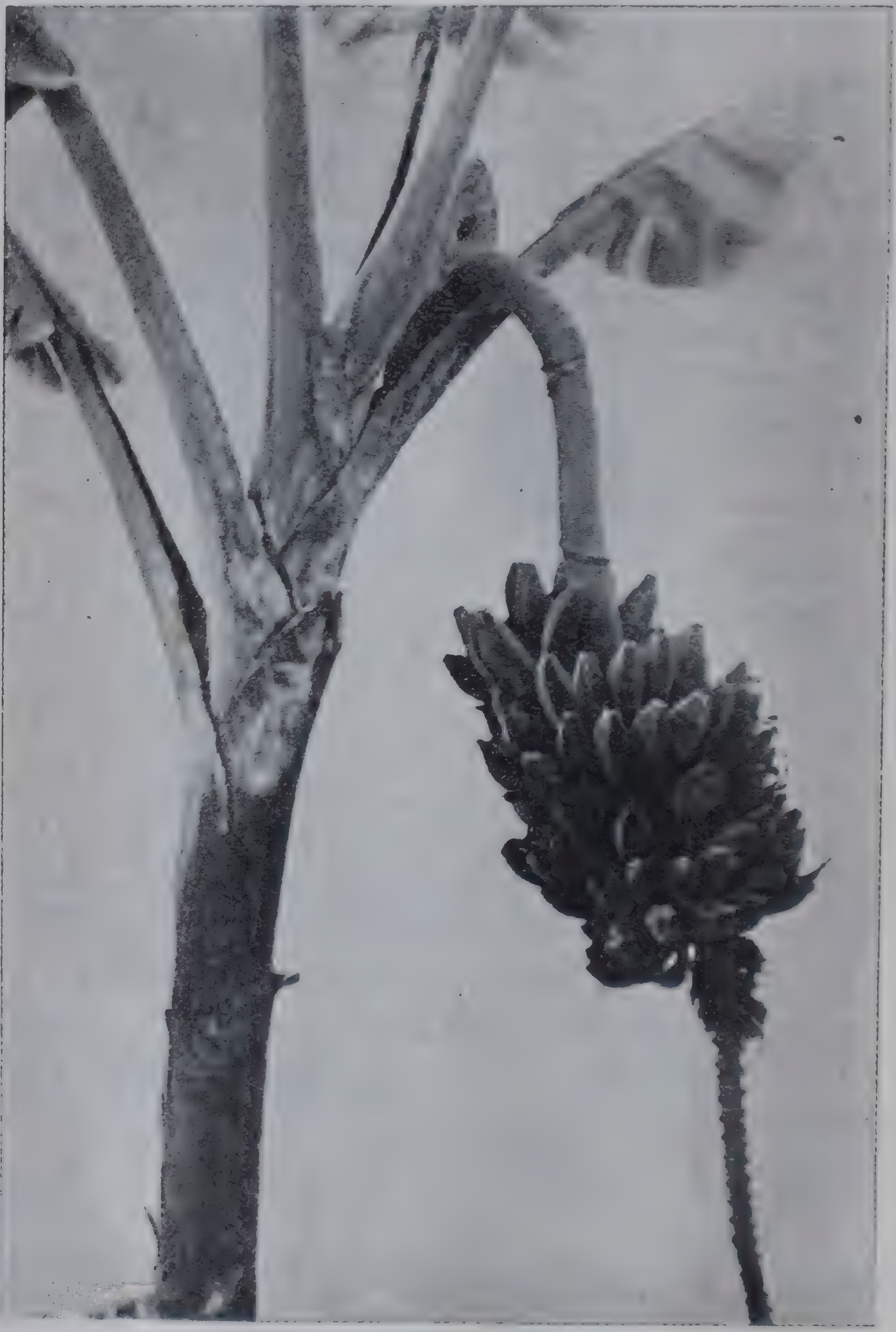

Fig. 78. Peyan.
(*Courtesy of the Botany Section, Coimbatore*).

for culinary purposes and ripe ones as table fruits of medium quality.

2. Ela Vazhai :—This is a seeded variety found in Chingleput district with fruits which are not edible and containing little pulp. It is mainly grown for its leaves. It is a tall growing, robust plant.

3. Musa Textilis:—This is a seeded variety of great repute elsewhere as a source of Manila hemp. It is a tall growing, robust plant with dark green pseudo-stem covered with bloom all over.

4. Kaio:—A heavy-yielding variety introduced to South India only recently from Hawai. Fruit is short, stout towards apex and can be used like Nendran. Bunch is closely packed and attractive. Sucker production extremely poor.

PROPAGATION AND PLANTING.

The cultivated varieties of bananas do not produce seeds, and the propagation has, therefore, to be effected by suckers or off-shoots formed at the base of the plant from the underground tuberous stem or rhizome. These suckers are removed from the mother plant when two or more feet high and one to six months after sprouting, and planted after separation. Much has been written on the proper selection of suckers, some recommending only the vigorous suckers of about four to five feet high with stout base and tapering towards the top and possessing narrow and small leaves, in preference to the wide-leaved, weak, slender pseudo-stemmed plants. The former are generally known as " sword-suckers ", while the latter are sometimes known as " water-suckers ". To some extent, earliness of bunching is associated with the large size of the sucker, and the securing of larger-sized suckers is facilitated by restricting the number of suckers in the mother plant to two to three per stool at the most. Suckers taken out from plants that have not flowered, are believed by some growers to be unsuitable for planting. Propagation by " bits " or pieces of rhizome having one or more dormant buds, is possible but is never done in commercial planting. There is a belief reported to be widespread in the West Coast that suckers emerging below the bunch of the mother plant or the one opposite to it form superior planting material, leading to larger bunch production than those emerging from other sides of the rhizomes.

The selected suckers are removed carefully, causing as little damage as possible to the mother rhizomes and to the young sucker.

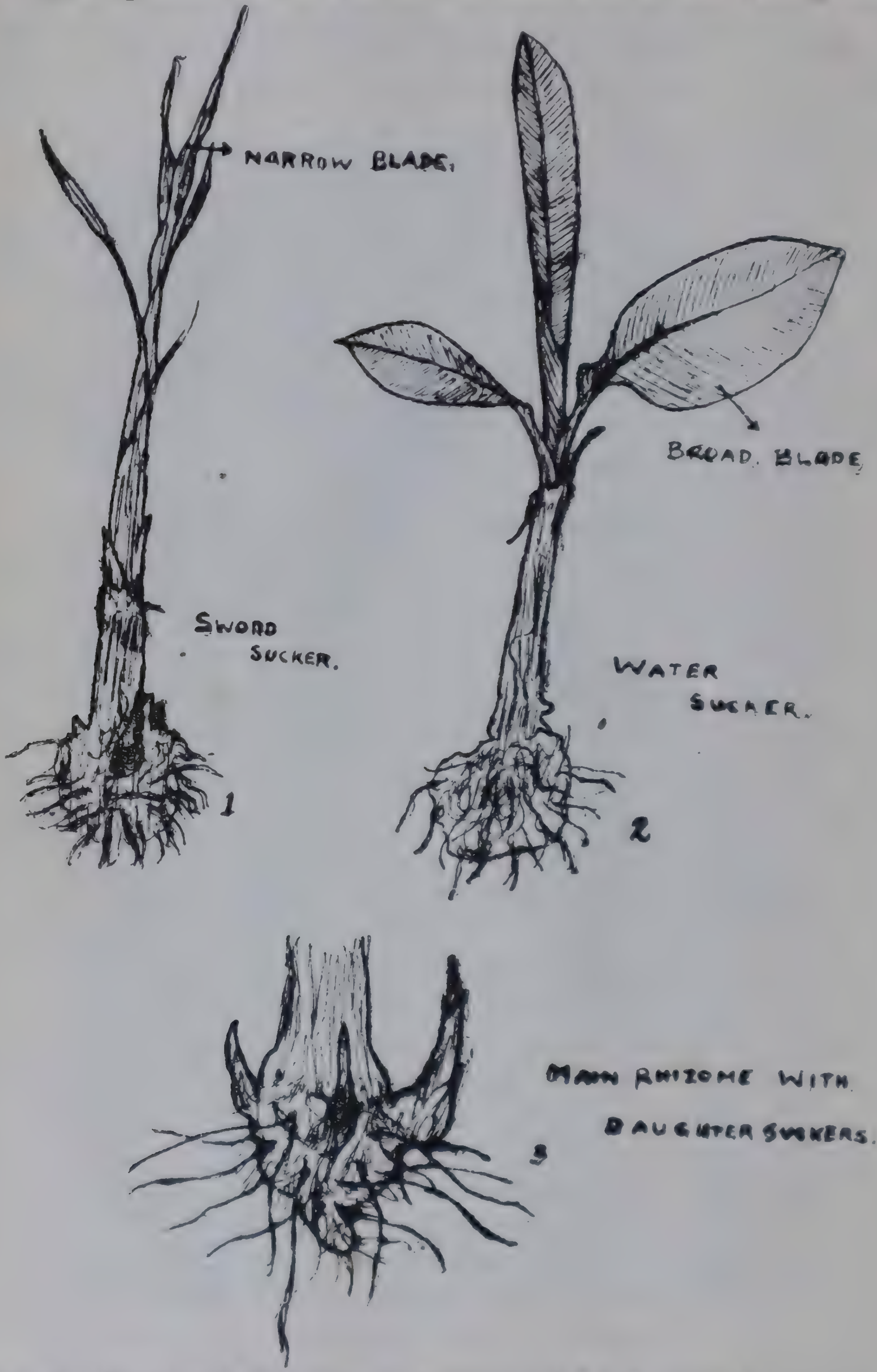
NARROW BLADE.
BROAD. BLADE
SWORD SUCKER.
WATER SUCKER.
1
2
MAIN RHIZOME WITH DAUGHTER SUCKERS.
3

Fig. 79. Sword and water suckers. (*Courtesy of Sri. K. S. Venkataramani*)

The separation is done with a hand tool or *mammuty* with a sharp edge. The lifted sucker will have a piece of the rhizome attached to it, with a few roots. It may be useful to remove neatly the damaged roots and parts of the rhizome immediately after separation. Some growers prefer to cut back the pseudo-stem of the young sucker obliquely at a height of about 12" above the rhizome. Many do not perform this heading-back, while some others top the suckers more severely to only three to four inches above the rhizome. The suckers may be planted soon after separation or four to five days of storing under shade. In some parts of Malabar, there is a practice of drying the suckers in the sun for a while after lifting. The benefits of this curing are yet not clearly understood, except that the dried suckers sprout out some days later than the fresh ones. At Taliparamba in 1944-'45 it was, however, reported that growth in the plants from dried suckers was more robust than those of fresh suckers.

The suckers may be planted by themselves or interplanted in areca, mango, jack, cocoanut, coffee, betel leaf, loose-skinned orange and pepper plantations. Coffee and orange plantations mixed with bananas are popular in the Lower Palnis and Sirumalai Hills in Madura District, while cocoanut and arecanut plantations intermixed with bananas are common in Mysore and the West Coast. In the last region the bananas are found mixed with other fruit and nut trees too both in home-compounds and plantations more or less as a perennial crop, as against the common practice elsewhere of retaining the plantations for only three to four years in wet lands and garden lands as a pure crop, in rotation with paddy, sugarcane or other agricultural crops.

The season of planting varies to some extent between the various tracts of South India. In most parts the colder seasons of the year are generally deemed unsuitable for planting. In the West Coast the planting is usually done from September to November. In order to secure better prices for off-season fruits, some do the planting in other parts of the year as well, provided irrigation facilities are ample in the dry periods. In other areas planting is often done with the break of the south-west monsoon in about June, and may continue thereafter till November. On the basis of the experience at Samalkot Agricultural Station, it has been recommended that for the Circars, June plantings are suited for varieties like Chakrakeli, Bontha and Mauritius but not as well suited for Poovan (or Karpura Chakrakeli), which takes a longer time to bunch. The last variety is best planted from November to January, as such suckers can be made to throw out bunches in six to eight months under proper care and to mature fruits three and a half to four months thereafter. The defect in this planting in the colder period is that, it entails great care in irrigating the young crop during summer, besides exposing the plants to high winds or cyclone damage during the bunching season. In some parts of Travancore where Nendrans are intensively cultivated as pure crop plantation, the planting is also done in December. On the Lower Palnis, including on the Sirumalai, April is the month when the daughter suckers are usually separated out and are planted. February-March is the most popular banana planting season in the wet lands along the Cauvery bank, such as in Trichinopoly, but in the perennial plantations of Tanjore, planting is done from January to June.

In paddy lands, the planting is often done without any preparatory soil culture in the delta areas of the Circars, the suckers being set amidst the paddy stubble in small holes. In Trichinopoly district all soil culture prior to or after planting is done by hand. The preparatory cultivation is done by *mammuty* digging, and the suckers are set down and made stable by merely throwing some soil around them. Elsewhere, holes of about one foot cube or just enough to accommodate the rhizome are usually dug just before planting in well-tilled or previously dug soil. Good facilities for drainage is of especial importance in wet lands. Ditches or trenches are therefore dug, each about two feet deep and one and a half feet wide in some parts or 15" wide and nine to twelve inches deep in other places, at intervals of about 30 feet or after every 2 rows. Such drains may run across the slope in sloping lands, as they also serve then as catch pits for the washed off soil. Similar drains are also made to run cross-wise after 4 or 6 rows of bananas in wet lands. The main irrigation channel in trenched planting lies on one side of the plantation at the highest level and has to be at right angles to the drains. This permits the irrigation water to flow to the plants through smaller channels without any hindrance from the drains, as the former run parallel to the drains. Such drains are also a common feature in mixed plantations of arecanuts and bananas. In some places, the drains also serve as irrigation channel. They are filled with water occasionally, and water is allowed to stand for about a day, after which they may be drained off. In well-drained garden lands, drains are unnecessary and the plants may be set in flat beds, each bed large enough to have four to six plants. In parts of Madura it is also customary to raise small mounds for planting bananas in wet lands. In most parts, the soil is given also a dressing of cattle manure before digging the holes and during the process of preparing the soil, while others resort to cattle or sheep penning in the site earmarked for the crop before the pits are dug. Application of a handful of ashes to each hole is common in the West Coast, where cattle manure application is sometimes discounted on the score that it may harbour grubs of rhinoceros beetle which causes severe damage to the rhizomes.

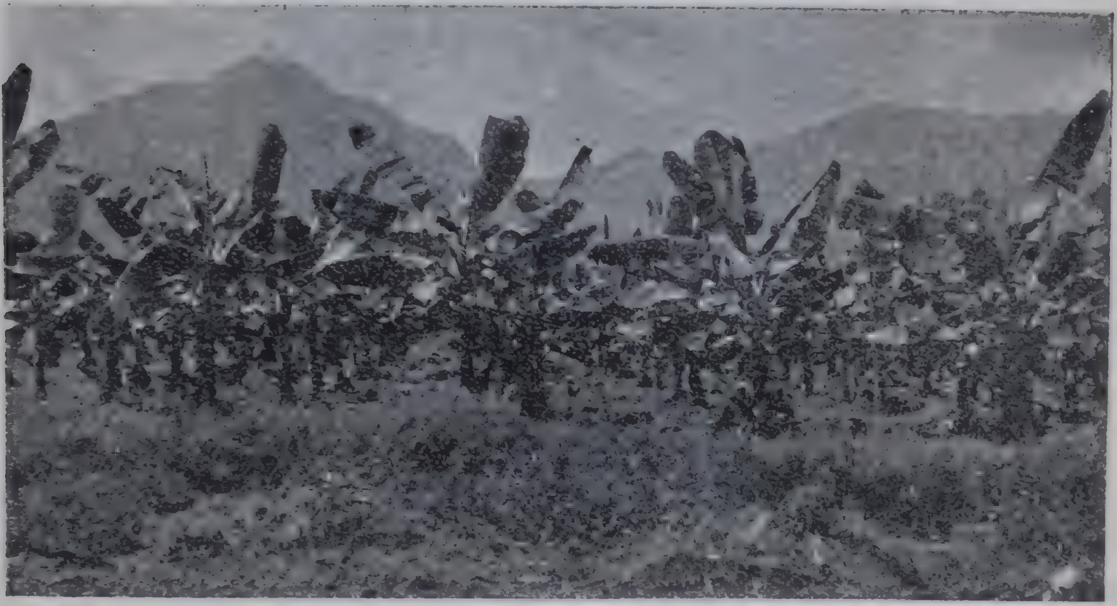

Fig. 80 Young banana plantation on the irrigated sections of Coimbatore Dt.

Some have recommended that, filling up of the holes with a mixture of wood ashes and soil up to three-fourths full should be done invariably before the planting, and that 20 to 30 cartloads of farm yard manure should be applied to the land before the pits are dug. When rotated with paddy in wet lands in Trichinopoly no manuring is usually done before the planting of suckers.

There is some divergence of opinion in South India in regard to the spacing in banana plantations. Planting seven feet apart in the row and eight feet between rows is common in most parts of South India. Seven feet on the square on poor soils and eight feet on the square on fertile soils, have been suggested for the Circars for most varieties, but for Chakrakeli a spacing of six to eight feet, for Bontha eight to ten feet, and for Mauritius five to seven feet have also been considered adequate. For Nendrans, a nine-feet spacing is common. With the varying distances adopted in South India, an acre holds roughly 550 to 1,250 suckers, while in many other countries the number is much less, as 12 to 15 feet spacing is common. A recent tendency in parts of Trichinopoly is to plant 1,100 suckers on an acre, of which 900 are of Poovan, and 200 of Nendran. The latter are grubbed out after the first harvest in about 12 months. It is obvious that spacing has to depend on the variety, soil and nature of cultivation, and therefore, a uniform spacing to suit all South Indian bananas is impossible.

The suckers are planted upright in the centre of the pit in a manner to bury the rhizome completely in the soil along with an inch or two of the basal parts of the pseudo-stem. The soil around the stem is pressed firmly, and a good soaking irrigation or hand-watering is then applied to the plants. To reduce the damage from high winds, the establishment of effective wind-breaks becomes necessary in all parts of South India. A quick-growing plant like castor and *Sesbania grandiflora* are the popular plants used in the wind-break belts, by planting in double or triple rows closely to each other.

AFTER CARE.

Irrigation :—Though the banana thrives under well-drained soil conditions, it also needs ample water for success except when raised under rain-fed condition as on the Lower Palnis or under the perennial system as practised on *padugai* lands near Aduthurai. If there are no rains immediately after planting, a weekly irrigation is generally given to the young plants except in rain-fed plantations. Flooding is the method of irrigation in small areas planted to Nendrans in Malabar. Filling up the drain-cum-irrigation channels with water for about a day and then draining it off is a common practice in wet lands in certain parts of Tamilnad. In mixed plantations of arecanuts and bananas, water is sometimes led from a main channel to small square or rectangular beds made around a few stools and areca trees. With pure banana plantations, the irrigation is also sometimes similar to that adopted for citrus trees, i.e., the water from the main channel is led between the plant rows alternately, in smaller channels, from which water enters the beds around each stool. The beds are small in young plantations and later are increased to cover the entire space, forming long rectangular beds at the rate of one for each row or a part of it. The interval between irrigation during rainless and dry periods may vary from five to ten days, depending on the rapidity with which soil moisture is depleted in the given site.

Fig. 81. Rainfed banana plantation on Lower Palni.

Manuring :—The banana being a gross feeder, plenty of organic manure is necessary for its success. As previously mentioned, it is usual in some parts of South India to apply manures to the soil before planting, while elsewhere some growers prefer to apply these a little while after planting, roughly 15 days to four weeks after planting. A second dose of manure is applied by many growers about five to six weeks after. A third application may follow in some plantations about two months later. The common manuring practice in wet lands of Trichinopoly consists of a first application of sulphate of ammonia at 224 lbs. per acre, applied only on one side of the suckers in April-May. The second application follows in the fifth or sixth month of planting and consists of 6 bags (1,000 lbs.) of groundnut cake and 224 lbs. of ammonium sulphate. The third and the last is done in the ninth month and comprises of 224 lbs. of ammonium sulphate or ammophos. In the perennial banana lands near Aduthurai in Tanjore district manuring is done once a year from June to January with only a basket of village refuse or dung per stool.

The kind of manures applied and dosage are seen to vary from place to place to a great extent. In Travancore, it is reported that for Nendrans, besides the application of a layer of cattle manure to the soil during preparatory cultivation, the same manure is applied to the plant and dug in around the trees about ten days after planting. This is followed by an application of dried leaves and ashes in the soil at a depth of four to five inches immediately round the pseudo-stems within a radius of about two and a half feet and worked in. About three to four months after planting and with the break of south-west monsoon, oil cakes at the rate of one pound per plant mixed with ashes are given to the plant in the irrigation basins and hoed in. In about July, a quarter pound of niciphos is applied per plant and covered with soil in shallow furrows around the pseudo-stems. In the Circars, there is a practice of cattle or sheep penning the area before planting, and this has already been referred to. About three to four weeks after planting, a light dose of manure consisting of one-half pound of groundnut cake has been suggested by some to be applied around each plant and hoed in. About five to six weeks afterwards, another dose of manure, consisting of one and a half to two pounds of groundnut cake per plant or its equivalent in the form of some other organic manure has been suggested to be applied around each plant in the irrigation beds and also hoed in. Another practice followed in some years at the Agricultural Research Station, Samalkot, was to apply about 20 cartloads of cattle manure and 1,000 lbs. of ammonium sulphate per acre. In some parts of Malabar, cattle manure is not favoured for fear of attracting rhinoceros beetle, as was mentioned already. Under such conditions, besides adding a handful of ash to each pit before planting, about 20 lbs. of green leaves and five lbs. of ashes are applied to the plants when they have put forth three to four leaves after planting. This is followed by a larger dose of the same when the plants become three to four months old. Some are reported to apply a third dose of the same about two months after the above-stated second application. Burnt earth is also added in some places. Jacob has recommended for Madras Presidency an application of two baskets of well-rotten farm yard manure, or in its absence one and a half pound of powdered poonacs or two pounds of tannery refuse to each plant around the pseudo-stem, all to be covered with earth when the plants have put forth six to seven leaves. A second dose of any of these manures has been suggested by him to be given when the plants are about to flower. In subsequent generation for the ratooned crop, the manuring may be similar, but may be applied once when the mother sucker is about to flower and again when the daughter sucker puts forth seven to eight leaves.

A review of the banana manurial trials conducted in the different parts of Madras Presidency by the Agricultural Department has shown that though Madras soils are generally well-supplied with potash, applications of potash seems to serve a useful purpose in improving the yield. Nitrogen is also found to be important. At Palur, sugarcane trash equivalent to 1½ cwt. of potassium sulphate, five cwts. of groundnut cake and two cwts. of superphosphate per acre gave satisfactory responses, while at Samalkot, a combination of ammonium sulphate (2½ oz. per plant) and superphosphate (3½ oz. per plant) with a basal dressing of 10 tons of farm yard manure per acre was found satisfactory both for the January and June planted crops. The review has also indicated that potash in the form of potassium sulphate or ashes may be necessary, besides ammonium sulphate or oil cake and superphosphate for securing best yields. It has been recommended that a good dose per acre of bananas may be a mixture comprising of potassium sulphate (1½ cwt.), groundnut cake (5 cwt.) and superphosphate (2 cwt.). Potash applications have been found to have no influence on fruit quality. It has to be emphasized that, with each application of manure or fertilizer, a good irrigation should be given to the plants immediately the manures or fertilizers are dug in the soil. In some wet land plantations as well as in perennial plantations on *padugai* lands or on hill slopes, surface irrigations are not done. In the former areas filling the trenches with water is found sufficient, while in the latter, the growers depend only on rains to help in the decomposition of the manures. Since the banana is a surface feeding crop, heavy digging of the soil for incorporating manure is not advisable. This is one of the reasons why heavy applications of bulky organic manure are usually recommended to be done to the soil before planting. Green manuring is a practice recommended in some parts of the world for the banana, but is not resorted to in South India.

Culture :—Inter-cultivation of banana plantations by bullock power is rarely done and the soil culture including the weeding, formation of basins and channels, and manure incorporation are effected only by hand tools like *mammuties.* The weeding operation is specially important in banana plantations in the initial stages, till the plants shade the ground. Even after this, weed growth is generally abundant because of the heavy irrigation to the crop, and occasional cleaning with hand tools or *mammuties* becomes necessary, but taking care not to work the tools more than a couple of inches deep. Two *mammuty* diggings are common in wet land banana areas in Tamilnad, and these are given usually in the third and sixth month of planting. Hand weedings may be done in other periods of the year too. In the perennial plantations in Tanjore district, the number of diggings with *mammuty* may sometimes be as many as ten in a year. Once in about three years, when plants get pushed above the soil surface, a sucker is removed from the stool and planted in a pit close by. This lowering of the root zone is done at the time of periodical digging.

Neither the green manure nor the inter-crops are raised in pure crop plantations, except in parts of the West Coast. Yams (*Dioscorea sp.*) are popular in Travancore, and these are planted in Nendran

Fig. 82. Intercropping young banana plantation.

groves at the rate of about three plants to a banana plant, with the break of south-west monsoon, just outside the irrigation basins. If spacing is wide, some short duration vegetables can also be grown in the first few months.

If the season immediately after planting happens to be the warm summer months, it is not uncommon for the growers to protect the young plants from sun's heat by wrapping the pseudostems with dried leaves of banana or similar available material in the locality. Filling up of gaps in the plantation is also necessary, as soon as the casualties are observed within the first 15 days of planting. Propping of bananas with the aid of wooden or bamboo poles is an important or even an essential operation to avoid the breaking off of the plants during high winds in most parts of South India. This operation is done just before the emergence of the inflorescence, or in many cases after the bunches are formed. Either single poles or double poles tied into fork at the upper ends are used. With the dwarf variety like Mauritius or with strong-stemmed or strong-rooted varieties like Bontha and Rastali, propping seems unnecessary in some situations.

PRUNING.

Occasional removal of suckers, hearts and dry leaves are the operations that have to be attended to during the life of the plants. Mattocking or the process of cutting back the old pseudostem after the harvest of the bunch, is an operation that has also to be done with care and in time. Ordinarily daughter suckers commence to appear from the base of the plants from about the third month of planting, but in suckers carelessly removed as to include large slices of the rhizomes, some buds may shoot up to form new suckers even earlier than the above period. Jacob has recommended that in Madras Presidency, it would be best to remove the first and second daughter suckers as soon as they appear above the soil, while the third daughter sucker may be allowed to grow for the succeeding generation. Those that follow the third sucker are also suggested to be removed. This system, according to Jacob, will enable the harvest of four bunches from a stool in the course of about three years. In the fourth year, he advocates the retention of three to four healthy daughter suckers for each stool for the purpose of leaves. In the case of November to January plantings in the Circars, one daughter sucker for each stool has been suggested to be retained in the stool after mattocking the mother plant in the following January. In the rainfed banana plantations on the Lower Palnis the practice commonly adopted is to remove all surplus suckers only once a year, generally in about April. Many growers in other parts of the province also do not believe in retaining a daughter sucker till about the flowering period of the mother plant. In Trichinopoly all daughter suckers are removed in the 'filler' planted Nendrans, while in Poovans only one sucker is left in the ninth month for the second crop, the rest being removed every month. Whatever the season or period of desuckering may be, it seems advisable to remove occasionally the dried leaves of the plants, which are often thrown into the drains. Roughly three times a year the removal of dry leaves is done on the Lower Palnis. The removal of the daughter suckers has to be done with care. They can be removed with a *mammuty* or a crowbar with flat and sharp ends, so as to remove them neatly with a piece of the rhizome attached at the base and without causing much damage to the mother rhizome. The removal of the cone-shaped inflorescence or heart from every bunch is done after the bunch is fully formed with all the female flowers setting fruit.

GROWTH AND CROPPING

From the studies carried out at Samalkot Agricultural Research Station, Narsimhan has found that the bananas make their maximum growth during the rainy months of July to November, the growth of the pseudo-stem ceasing about two to three weeks before the emergence of the inflorescence. By this time, commercial varieties like Poovan, Chakrakeli (white), Bontha and Mauritius make roughly a pseudo-stem length (i.e., up to the junction of the flag leaf from the ground level) of 100 inches each in the first two varieties, 109 inches in the third and only 56 inches in the last variety. The bunch lengths at the time of harvest vary from about 12 inches in Chakrakeli (white), 16 inches in Bontha, 20 inches in Mauritius, to 24 inches in Poovan (syn. Karpura Chakrakeli). The total number of leaves per plant has been worked out to an average of 25 each in Chakrakeli (white) and Mauritius, 27 in Poovan and 29 in Bontha. The time taken from the date of flowering to maturity of fruit is partly dependent on the seasonal conditions and is partly a varietal character, and to some extent depends on the irrigation facilities at the period. Those that are classed as long duration varieties were found not necessarily to take a longer time for maturity than the others. The number of hands per bunch was found to be a varietal character under similar conditions of soil and culture, though subject to be influenced by environmen and cultural variations. Under room temperature, the time taken for the harvested fruits to ripen was found to be only four days in Poovan and five days in Chakrakeli (white). The hands when separated from the bunches were found to ripen about a day earlier than when the whole bunch was kept for ripening.

Jacob reports that with the first crop, Nendrans as grown in Travancore under intensive plantation practices, and when the bunches are enclosed in cheap baskets made of plaited cocoanut leaves when the bunches are about quarter-full, the crop can be harvested within nine months of planting, while under ordinary cultural conditions in the rest of Malabar, the average duration is about 11 months. Some of the early Nendran varieties have been noted in Malabar to commence flowering in seven months of planting, with the fruits ripening about three months thereafter. Observations at Samalkot have shown that, with the June planted crop over 85 per cent of Chakrakeli, 83 per cent of Bontha and 75 per cent of Mauritius plants bunched by the close of the following January. Bontha bunches were ready for sale in about two months after their appearance, while Chakrakeli and Mauritius took about three or four months respectively. At Taliparamba, Mauritius proved to be the shortest duration variety in 1944-'45, followed by Nendran, while Kaio was the longest duration variety, with Chakrakeli close behind. Fruits could be harvested in nine months and 29 days after planting from the Mauritius. Of the eight Nendran varieties tried at Taliparamba, Chengaikodan took eight months to flower, while others took seven months. Mauritius threw out bunches at Taliparamba in 7½ months from planting in 1946-'47. Ney Poovan and Kaio were found to be the most shy-sucker producers. The Nendrans grown in Trichinopoly are harvested in about the tenth month of planting, while Poovans become ready from the 12th to the 14th month, and the second harvest from the 21st to the 24th month, when the plantation is removed generally.

The yield varies naturally to a great extent from locality to locality and from variety to variety. An average yield of four to five hands with a total of 30 to 50 fingers have been estimated as normal for Nendrans in Malabar, the estimated acre-yield being about 700 bunches. In a comparative trial at Taliparamba in 1946-'47, the average weight of Nendran bunch was only 18.0 lbs., while that of Mauritius was 40.1 lbs. with the mean number of fruits being 41.75 and 136.00 respectively. At Samalkot the yields have been shown to be 800, 900 and 1,000 saleable bunches per acre respectively from Bontha, Chakrakeli and Mauritius. On the basis of crop weight, it has been found at Samalkot that

Chakrakeli yields were 13,129 lbs. per acre of the value of Rs. 957 in 1924-'25 and 18,203 lbs. of the value of Rs. 1,327 in 1926-'27. Nayar has estimated the value of 700 bunches of Nendrans in Malabar from an acre to be only Rs. 270 in 1941, besides a small income of Rs. 36 from the sale of suckers and fibre etc. At Coimbatore, from a collection of about 100 varieties, it was found that Myndoli gave the highest crop yield per plant of 57 lbs., and Namarai the poorest with only one pound in 1944-'45. In 1942-'43, Pacha Montha Bathees produced the heaviest bunch weighing 41.78 lbs., though the number of fruits was the largest with Poovan, it being 180. In Trichinopoly the yield is estimated at 1,000 bunches in the first year, 800 bunches in the second year, and where the third crop is also harvested, about 700 bunches by that harvest. Poovan bunches there are well filled, giving 10 to 14 hands and weighing 25 to 40 lbs. each. An average yield of 40,000 lbs. from the first crop per acre is not unusual. According to the Central Agricultural Marketing Department (1945), the yield of bananas average to 155 maunds per acre in India, with a total production of 109,841,000 maunds for the whole country in 1940-'41. Though the fruits are available all the year round, October to April are the months of heavy supplies in Madras, while in Travancore the supplies are the heaviest in June to September and low from February to April.

Ripening:—The bananas are rarely allowed to ripen on the plants. After harvesting the bunch from the plants by means of a bill-hook or sickle, it is ripened in several ways—by smoking the fruits, storing in godowns, exposing to sun, placing the bunch over a hearth or by covering the bunch with green leaves. These various methods have been briefly described in the Report on the Marketing of Bananas by the Central Marketing Department. Suggestions have also been made there on grading, packing, transport and marketing. In South India the harvested bunches are usually transported either as naked bunches or with a lining or wrapping of banana leaves. The hill bananas are however commonly sent after separating the hands from the bunches and after wrapping or lining the hands with dried leaves. One of the common ways of ripening is to heap the hands in a room, packed to about three-fourths of its capacity. The fruits are then covered with leaves and a fire is lit in one corner of the room using cattle dung cakes, after which the room is closed and made as air-tight as possible. This treatment of smoking lasts from 30 to 48 hours. Another method followed in

Coimbatore district is to stock the hands in a corner of a room, cover with leaves and to place on the ground inside the heap a mud pot with mouth downwards and a hole on the opposite side. The pot is filled with cowdung cakes. A mud plaster is applied round the heap. The cake then is lit on which the smoke spreads through the layers of the fruit and helps to cure the fruits. Roughly, 24 hours is the period for smoking in summer and 48 hours in winter. On the slopes of the Nilgiris the practice is to dig a pit and then cover with a tin sheet or wooden plank leaving a small hole. The pit accommodates usually 12 to 15 bunches at any one time. On the bunches, banana trash is placed before closing the pit. Mud plastering follows to make the pit as air-tight as possible. Over the hole a mud pot with a hole at the bottom is placed after filling it with banana trash. Fire is then lit through the hole and this generates smoke which gets diffused inside the chamber in due course. Ordinarily three such smokings are given with an interval of twelve hours in summer and four in winter to complete ripening. A preliminary trial in 1946 at Burliar showed that the application of vaseline to the cut stalk ends of bunches cause an earlier fruit ripening by about four days, besides fostering a uniform colour of the fruit. Insertion of ground garlic piece within the fruit stalk was also found to quicken fruit ripening by about four days in Kodur. When both these trials were repeated, the results were conflicting, so that further work seems necessary to throw light on them.

Storage:— The Central Marketing Department considers that cold storage methods will not pay for a relatively cheap fruit like the banana, except perhaps for developing an export trade. At Poona some varieties were found to ripen well at 60° F. and 68° F. Application of vaseline, a layer of clay or coal tar was found to prevent the rotting of the stalk end. Storing of banana is rarely done, as the fruits are loaded for despatch as soon as harvested. If storing becomes inevitable, it is done under tiled roofs.

Economics:—Exact figures regarding the cost of production of bananas have been maintained at a number of stations in Madras Presidency. At Anakapalle, a net profit of Rs. 756 was realised in 1945 from a ratoon crop in a mixed plantation planted to about 20 varieties. In 1942-'43, the net profit was much less, it being only Rs. 537 per acre for the ratoon crop and Rs. 640 for the plant crop. At Samalkot in 1927, a net profit of Rs. 900 was got from a mixed plantation of Bontha, Mauritius and Chakrakeli, while in 1928 the profit rose to Rs. 1,000|- per acre.

PRODUCTS

The perishable nature of the fruit, the lack of refrigeration facilities as well as the restrictions in transportation facilities as those imposed during the last war, serve to hinder the course of development of banana growing industry in certain producing areas, while the military demand and special facilities provided for transportation of the fruit augmented production in certain localities as those in and around Kodur during the war period. To meet the gluts in producing regions, dehydration of bananas has been suggested as a means to tide over temporary difficulties as well as to facilitate the absorption of the surplus even in normal years. Since the dehydrated bananas can be transported cheaply and conveniently, a wider market becomes possible. Banana "figs" and flour have been the two important industrial products of the fruit which have been worked upon and found most suitable for large-scale manufacture. For preparing banana flour, fully matured but slightly unripe bananas were taken and dipped in boiling water for two to three minutes, to facilitate peeling. In some trials, however, ripe fruits were also utilised. After removing the peel by hands covered with rubber gloves, the pulp was cut into halves or quarters, lengthwise. The slices were then spread on single layers on slat bottom bamboo trays. The trays were then stacked either inside the "home drier" or in a specially constructed room. The air inside the room or chamber was maintained at 145° F., while inside the room or the chamber was heated by means of a charcoal oven or a fire place. By adjusting the ventilators, the temperature inside the chamber was maintained at 145° F., while inside the room the temperature ranged from 135° to 138° F. When the slices were dry they were removed from the trays, powdered and sifted, and finally stored.

In order to obtain a more attractive and whiter flour, the slices in some of the trials were exposed to the fumes of burning sulphur for 20 minutes before drying.

For the preparation of banana "figs" the same process as outlined above was adopted except that, the slices after dehydration were cut into small pieces and stored as such.

A home-drier has been successfully used at Kodur for drying the fresh fruits. It is a box 3 ft. x 1 ft. 8 in. x 2 ft. 6 in., resting on a wooden stand 2 ft 6 in. high. An iron sheet forms the bottom of the box or chamber. The inside of the door and the portion against which it clings when the chamber is closed are lined with asbestos. The box is provided with two longitudinal openings on the top, each 12 in. long and 1 in. broad for the escape of moisture from inside the box. Another small aperture is provided on the side opposite to the door, to take in a thermometer. The chamber has space for fitting seven trays with bamboo slat bottoms. These trays can be stacked in a staggering manner to allow free circulation of hot air.

The source of heat for the chamber is a charcoal oven which is placed on the ground below the centre of the iron sheet bottom of the chamber. The oven is divided into three sections, the top one for piling up charcoal for ignition, the central one with a perforated bottom for stoking and for regulating the removal of ash through the perforated bottom, and the bottom portion for collecting the ash. The central section has got two doors or ventilators provided with collapsible shutters. They permit stoking the fire and help to a certain extent to regulate the intensity of the heat.

The oven is fitted up with a chimney which touches the iron sheet bottom of the chamber. This funnel is provided with two windows opposite to each other, and these are with collapsible metallic doors. These help in feeding the oven with charcoal from time to time and also in regulating the heat to some extent. The temperature inside the chamber can be further regulated by opening or closing the door of the chamber.

The chamber maintains a temperature of 145° to 150° F. when fully charged. To ensure uniformity in the rate of dehydration, it is necessary to alter the positions of trays by shifting those at the bottom to the top and *vice versa* two or three times in the course of dehydration. The drier has a capacity of dehydrating 30 to 40 lbs. of pulp at a time.

A dehydrating room devised at Kodur is more suitable than the home-drier for large scale work. It is a room constructed of bricks and is eight feet long and seven feet broad, and eight feet six inches high at the centre. The roof is made of galvanised iron sheets. The single door is 6 ft. 6 in. x 3 ft. 6 in. and is of ordinary country wood. On each of the two side walls are fitted wooden struts over which the bamboo slat-bottomed trays can be stacked in layers with the help of a few bamboo sticks. Opposite the door a fire place is built opening to the outside. The fuel consisting of any trash, prunings or dried leaves is ignited through the fireplace from outside. The fireplace is closed by a galvanised iron drum from the inside of the room, and this radiates the heat. A galvanised iron chimney of 4 in. in diameter is built inside the room over the iron drum of the fireplace and rises up above the roof.

When fully charged the room has a temperature range of 135° to 138° F. As in the chamber, a slight shifting of the trays is necessary inside the room also, to ensure uniformity of dehydration. The room is estimated to cost Rs. 150 to Rs. 200 for construction. It can take about 250 lbs. of pulp at a time.

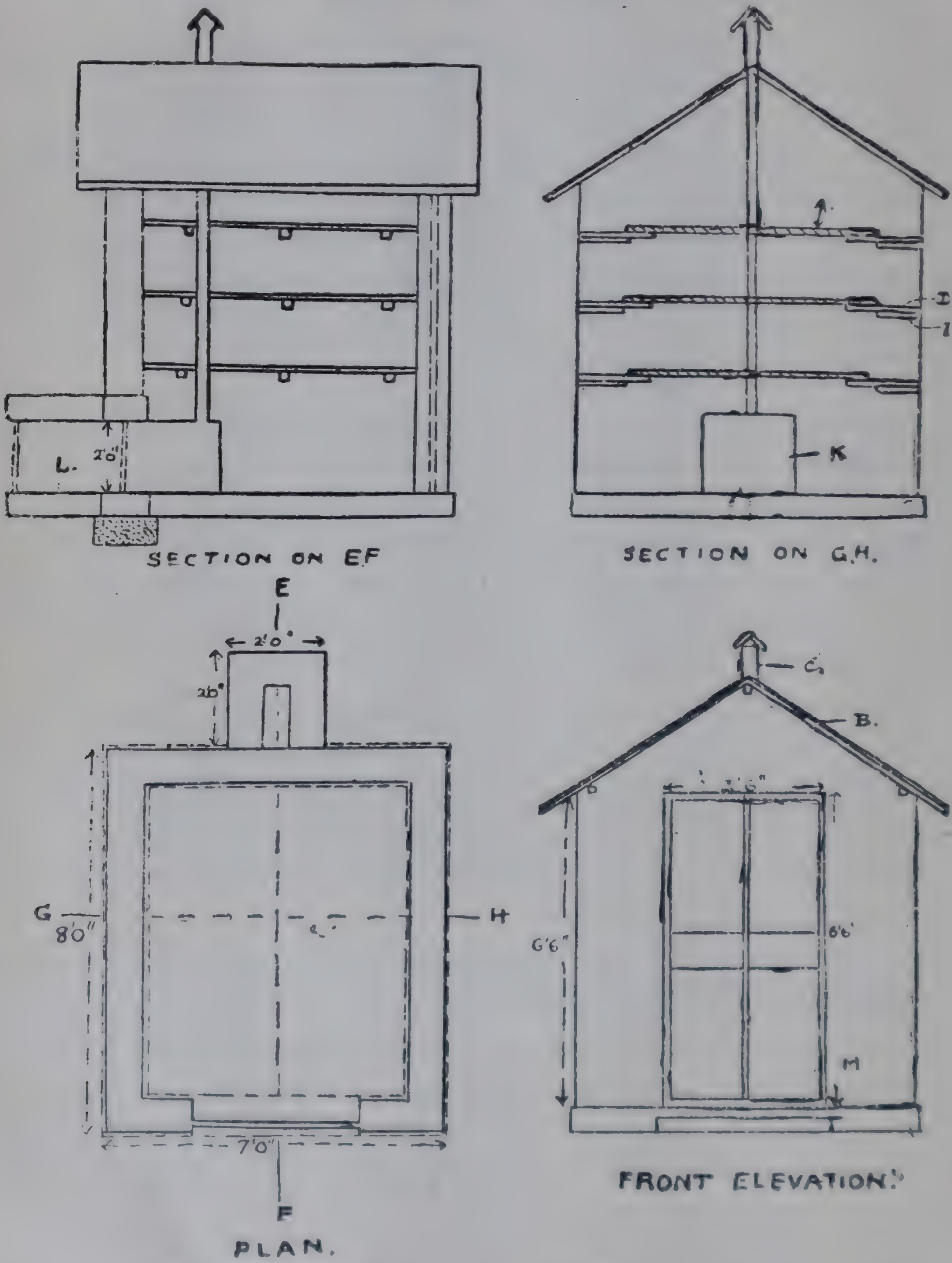
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Fig. 83. Plan of a room for dehydrating bananas.

Although the above methods were the only ones tried at Kodur, it is possible to dehydrate bananas on a large scale with the help of tunnel dehydraters. These are heated by steam or flue pipes, and hot air is forced by means of high velocity fans. The quality of the product dehydrated in this manner is stated to be unsurpassed. The short drying time possible in this is a great advantage. It is reported that in West Indies attempts have also been made to prepare flour from banana pulp by means of drums and vacuum driers. At Kodur, however, the "home-drier" and the dehydration chamber have been found to be quite suitable for the purpose.

Exposing the slices to sulphur fumes for about 20 minutes helps to improve the colour of the final product, rendering it more attractive than the "figs" prepared from unsulphured fruit. Among the varieties tried, the best quality "fig" was obtained from Pey Kunnan variety. Nendra Padathi and Ney Poovan "figs" were also good. According to the Processed Food Stuffs Directorate, "figs" of Kapur and Nendran were not up to the mark as they absorbed moisture in storage. The percentage of recovery as "figs" on the basis of fresh fruit weight was the highest in Pey Kunnan, namely 34.7. In the case of Ney Poovan it was 32.0, while in the case of Nendra Padathi it was only 20.6.

The ripe fruit does not seem to be well-suited for the preparation of "figs". In general, the product from such a fruit even after sulphuring becomes dark in storage.

Among the varieties tried, Bontha Ashy, Bontha Green and Virupakshi took the least time for dehydration, possibly owing to their solid flesh and low moisture content. At a temperature of 140° to 150° F., these varieties were completely dehydrated in nine to ten hours, as against 15 to 22 hours taken by other varieties.

In the case of flour also, sulphuring the slices gives a far superior product. Flour from ripe fruit is definitely of a better taste and sweetness than that from unripe fruit. Flour from ripe fruits of Virupakshi, Pey Kunnan and Karpura Chakrakeli is of a very good quality and is suited for making beverages, not inferior in flavour to such well-known proprietary products as Ovaltine.

It is, however, much easier to prepare flour from unripe bananas. Such fruits take less period for dehydration and are easily converted into flour after dehydration. Fully mature fruits of certain varieties like Karpura Chakrakeli develop their characteristic ripe peel colour within about an hour of stacking the slices inside the dehydration chamber.

Like the ripe fruits, unripe fruits of Virupakshi, Bontha Green and Bontha Ashy could be dehydrated more quickly than other varieties. Kareem Kadali, though it dehydrates quickly, cannot be as easily peeled by dipping in warm water as the other bananas.

Wide differences were exhibited by varieties in regard to the percentage of recovery as flour. Nendran, inspite of its thick peel, produced the highest recovery, namely 27.6 per cent., and considered to be the most economical for flour manufacture. Pey Kunnan, with a recovery of 21.2 per cent., Bontha Ashy with 21.6 per cent, Bontha Green with 20.4 per cent., Kareem Kadali with 21.9 per cent. and Ney Poovan with 22.8 per cent are other suitable varieties from the above point of view. Varieties which gave low recovery of flour are Karpura Chakrakeli, Mauritius and Pedda Pacha Arati, with percentages below 15. The bananas, as a whole, compare favourably with guavas, in which fruit the recovery of flour was only 12 per cent. of the fresh fruit weight.

Although banana flour cannot stand comparison with such staple foods as wheat, rice or potato in its protein and mineral contents, it possesses certain valuable auxiliary food factors such as vitamin B complex and vitamin C and also available iron to a fair degree. It is these factors and not the protein content alone that have led certain authorities to recommend the production of dehydrated banana products as children's food. While banana flour may not replace staple food like rice or wheat, it should certainly help as a valuable substitute for the staple foods in times of scarcity. There is no doubt that it deserves popularization in preference to tapioca and arrow root flours.

In regard to the food value of banana flour, a writer in a Jamaican Journal (The Journal of the Jamaican Agricultural Society, September, 1941; page 334) asserts that it is superior in carbohydrates to wheat flour but inferior in protein or flesh-forming values, very palatable and particularly adapted to persons of weak digestion organs. He refers to cases of patients who were unable to keep down milk or other foods, but easily retained banana flour made into a thin gruel and flavoured with lemon or lime juice and sweetened with sugar. He adds that the starch in it is particularly easy of solution and digestion in the alkaline juices of the body. Banana meal is also reported by him to be used with safety by persons who do not want to put on flesh but wish to be fit and strong.

USE OF BANANA FLOUR AND "FIG":—Attempts have been made to work out methods of preparing from the banana flour and "fig" a large number of appetising dishes and beverages. The results of these attempts have disclosed numerous possibilities which remain yet to be fully exploited. A number of recipes which have already been tested have been published by the author in the form of a leaflet of the Madras Department of Agriculture.

BANANA FIBRE

Hard fibres are of prime importance during peace and war times, specially for naval and marine cordage. Because of the rare combination of tensile strength, water resistance in it and of its durability, Manila hemp or abaca is considered to be the most valuable and important among the hard fibres. Bananas are allied to the abaca-yielding, *Musa textilis,* and over 50 million pseudo-stems of bananas are estimated to be available annually in South India for fibre-extraction. Practically all of this raw material is left unutilised at present and was once thought to provide an yet unexploited source for a fibre industry, which may reduce the region's dependence on the importation of Manila hemp on one hand, and provide additional or supplemental source of income to the banana growers. Work done by the author has shown that the maximum acre-yield of fibre from a cultivated banana variety was about 100 lbs., and to extract this quantity it would require roughly 8.7 persons at the rate of 11.5 oz. per man per day. This works out approximately to Rs. 4-8-0 on fibre-extraction at the point of production per acre, or roughly at Rs. 6-4-0 per pound of fibre. According to the normal approximate market rates in peace times, this is too high a cost to entitle the banana fibre industry to be ranked as promising or remunerative. Fawcett (1921) has inferred that cultivation of *Musa textilis* for Manila hemp will not be remunerative when the production falls below 850 lbs. per acre. The estimated yield of Manila hemp in South India being less than one-sixth of the above limit, denotes that abaca production will be uneconomic here.

It may, however, be argued that labour should not be the main factor, since the extraction of fibre is likely to be done largely in villages during the slack seasons or periods when there is usually no other occupation or work to keep the persons engaged, and that in banana the fibre extraction is only a secondary occupation after the fruit harvest. Be that as it may, the progress of the banana fibre industry is bound to be affected by research on the improvement of extraction methods. Even though the improved Proudlock machine has come off in an unfavourable light in the studies made by the author there is justification for the hope that it would be easy to devise improvements such that would increase appreciably the fibre output per man per day to many times over that shown as possible by the primitive hand-extraction method. It is towards this important line of work that the author desires to make a plea to those mechanically minded persons, who have in their hands a potent means to contribute a great deal to the weal of the thousands of banana growers all over India, and particularly in the south, where enormous scope exists to expand banana farming. Even though banana fibre may not compare with the best trade samples of imported Manila hemp, the varied uses to which the former can be put—cordage, gunny and carpet making, inferior textiles, nursery bandaging material etc., justifies the development of the fibre industry. A similar hope was expressed by a Committee (Agricultural Research Institute, Pusa Bull. No. 16, July, 1909), which though condemning the banana fibre as far inferior to that of Manila hemp, proceeded to conclude that banana might give paying results for fibre after producing fruit.

PESTS AND DISEASES

Fortunately for South India, pests and diseases of any serious import have been characterised by their absence in the region. Most of the damage reported has been confined to defective plantation practices such as those from water-logging, ill-drainage and selection of adverse sites and soils. The notorious Panama disease of other banana-growing countries of the world, which had often threatened to wipe out of existence the banana-growing industry in Jamaica and West Indies, has not figured among the main concerns of the South Indian banana grower. Breeding of varieties immune to the Panama disease has rightly been the most prominent activity of the Imperial College of Tropical Agriculture since its inception in 1922, and has served to revive the hope of producers in Jamaica and West Indies. Among the pests and diseases of importance in South India, the following seem to deserve attention. The control measures given here are those recommended mainly by the Entomological and Mycological sections of the Madras Department of Agriculture.

1. PANAMA DISEASE OR WILT—*Fusarium cubense*:—This causes drying up of leaves and gradual wilting of plants. Bunches are rarely formed in the diseased plants, and when formed show signs of arrested development. The damage is not extensive, as the disease is not wide-spread. Use of healthy suckers and improvement of drainage are recommended.

2. FRUIT-ROT AND ANTHRACNOSE—*Gleosporium musarum*:—Pale grey spots appear on the fruits affected by this disease. This too is a disease of little consequence. Spraying with Bordeaux mixture has been advocated as a control measure.

3. STORAGE ROT—*Gleosporium* sp *and Diplodia* sp:—The rot of fruits manifests itself under storage, and sometimes causes fairly heavy loss. Careful handling of the fruits to avoid bruising or any sort of mechanical injury, and storing of fruits in well-ventilated places are suggested to prevent the damage.

4. BUNCHY TOP:—This is a virus disease, secondary infection of which occurs through the agency of an insect—*Pentalonia nigronervosa.* The disease is prevalent in a serious form in Travancore where a pest act has been enforced. In Madras Presidency also, the disease is reported as having occurred in stray plantations. Eradication of the diseased plants completely and their burial in deep pits are recommended to control the disease. The selection of suckers from disease-free clumps is also essential.

5. NEMATODE:—This leads to the formation of galls on the roots by some worms and later to their death. The damage is very casual.

List of References

1. Agri. Marketing Adviser to the Government of India—Report on the Marketing of Bananas, 1945, Government of India Press.
2. Cheesman, E.—Mutant types of the dwarf banana—Tropical Agriculture (Trin.) Vol. 10, pp. 4-5, 1933.
3. Chona, B. E.—Preliminary Investigations on the Diseases of bananas in the Punjab. The Indian Journal of Agricultural Science, Vol. III, Part IV, August 1933.
4. Fawcett, W.—The Banana—Its cultivation, Distribution and Commercial uses. Duckworth & Co., London, 1921.

5. Jacob, K. Cherian—South Indian Banana, The Madras Agri. Journal, Vol. XII No. 2, 19, 1933.

6. ,, —Bananas of the Travancore State, The Madras Agri. Journal September, 1942, pp. 277-287.

7. ,, —A Note on the Cultivation of Bananas in the Madras Presidency The Madras Agricultural Journal, June, 1939.

8. ,, —Bananas of the Mysore State, *ibid* Feb., 1942.

9. Jogiraju, G.—Cultivation of Plantains on Wet Lands in the Godavari Delta, Bull. No. 93, Madras Agri. Dept., 1928.

10. Naik, K. C.—Future of Indian Bananas. The Gardener, Vol. III. No. 2, 1939.

11. ,, —Dehydrated Banana Products and their Food Value, The Madras Agricultural Journal, December, 1943.

12. ,, —Banana Recipes, Leaflet No. 117 of the Madras Agricultural Department, 1943.

13. ,, —Fruit Personalities—Banana, *Mezhichelvam* (in Tamil), Madras, 1946.

14. ,, —Banana Fibre Investigations—Indian Journal of Horticulture, December, 1944.

15. Narasimhan, M.—Preliminary Studies in Plantains Grown in Madras, The Madras Agricultural Journal, February, 1937.

16. Nayar, P. Narayanan—The Nendran or Malabar Plantain, The Madras Agricultural Journal, December, 1941, pp. 470-473.

17. Venkataramani, K.S.—Studies on Indian Bananas—Proceedings of the Indian Academy of Sciences, Vol. XXIII, 1946.

18. ,, "Kaio", an imported banana variety.—Current Science, April, 1946, 4, 110.

19. Cheesman, E. E.—Principles of Banana Breeding. Tropical Agriculture (Trin.), Vol. II, pp. 132-37, 176-81, 203-09, 1934.

CHAPTER IV

HILL FRUITS OF SOUTH INDIA

Introduction:—Primarily a region suited to tropical and subtropical fruits, South India is recognised to lie outside the ideal zone for the production of fruits of the temperate region. Thanks to the modifying influences of altitude, however, endeavour has been made to raise most of the temperate zone fruits, in some cases at least with marked success. While the climatic conditions even on the higher elevations of South India cannot be comparable to the temperate zones in the north of India in regard to the extremes of cold, and are more aptly designated as moderate, it is nevertheless found possible to grow certain of these exotic fruits and make them yield crops sufficiently remunerative to the producers, and to reduce the region's dependence on other parts for the supply of this particular group of fruits.

Realising the potentialities of the higher elevations of South India, a pomological station was established at Coonoor in 1920, at an altitude of about 5,800 feet above the mean sea level, for serving as a testing ground for various fruit introductions. A number of pioneer attempts has also been made by individuals on the Nilgiris, Shevroys and Lower Palnis, in the introduction and trial of the temperate zone fruits. Some attempts to try such fruits have also been made in lower elevations as those in and around Bangalore, near Anantagiri in the Agency tracts and in Wynad. Since 1941, when the Pomological Station, Coonoor came under the Fruit Section of the Madras Agricultural Department, the work on temperate zone fruits was extended and much information of scientific and practical value has been gathered, so that it is now possible to furnish with a measure of confidence an idea of the possibilities for the production of this particular class of fruits in the higher altitudes of South India.

Owing to the peculiar climatic conditions of these South Indian hills, a visitor from the temperate zone is often struck by the apparent incongruity of fruit wealth such as is found by the growing of the apple in close proximity with the tropical mango and banana. Topography rather than latitude, climatography as determined by temperature ranges, rainfall, elevation and soil rather than geography, should be the standards in delineating the optimum fruit zones in South India, as elsewhere. Accordingly, the more or less artificial divisions of fruits into those of tropical, sub-tropical or temperate zones cannot be applied strictly in dealing with the commercial fruit culture in South India. The designation of "Hill Fruits" is therefore considered more appropriate, and is accordingly used in this text.

Based on the experience of the trial of fruits on the varying elevations and topographical conditions of South India, it would seem desirable to include the apple, plum, pear, peach, strawberry, as well as the more sub-tropical fruits like the persimmon, Cape gooseberry, cherimoyer and passion fruit, under the "Hill Fruits." Some of these like the apple are no doubt grown commercially even on elevations as low as 2,500 feet from the mean sea level as in Bangalore, while the peach is sometimes found as stray trees even down to the sea level. Even so, the Cape gooseberry and passion fruit are crops that are very adaptable to a wide range of elevations. Nevertheless, it is considered that they are best treated under the caption of " Hill Fruits," if only because they have so far attained the largest commercial importance on the higher elevations of South India. On the same basis, the mangosteen, durian, litchi and avocado are dealt with in the present work under humid zone fruits. The remaining tropical fruits, including the grape, fig and pomegranates though are being produced in more than one zone, are dealt with in separate chapters, because of their greater commercial importance outside the hills and humid zones of the lower hills or hill slopes. The jack, papaya, annonaceous fruits, carambola and bilimbi are of more or less equal importance both in the plains and in the humid zones of lower hill slopes, and are therefore treated in a separate chapter.

I. APPLE *(Pyrus Malus)*

As has already been indicated above, the apple growing region in South India is mainly restricted to higher elevations exceeding about 4,000 feet on the Nilgiris, Shevroys and Palnis, with a small area planted to some hardy varieties like Rome Beauty in lower elevations of about 2,500 to 3,000 feet in and around Bangalore. Possibly because of the lack of a forcing winter, combined with the high temperature ranges in summer; apples never attain in South India the tree vigour and performance associated with this fruit in Kulu valley and Kashmir, nor do the trees live as long. The peculiarities of apple growing in South India are further brought out by a comparison of the grove practices, some of which as are adopted in Bangalore to secure two fruit crops in a year seem to have no parallel in any part of the world.

According to an estimate by the Provincial Marketing staff, Madras, some 2,400 apple trees were under cultivation in that province in 1942-43. The estimated area and production in Mysore State are reported to be 200 acres and about 13,000 maunds of fruits per annum respectively.

Like all other tree fruits, the apple relishes a deep soil of uniform texture, preferably of a loamy nature.

Soils underlain with rock and kunker or similar impervious layers at about two feet below the surface have sometimes been used in Mysore State, apparently with no ill-effects in the first 10 or 12 years of the life of the trees. Since the trees rarely live beyond this age in the State, it is difficult to condemn such shallow soils for the fruit under the peculiar conditions of their culture. In any case, good soil drainage appears very beneficial to apple growth and production, and this has to be provided for, regardless of the soil depth.

VARIETIES

From a trial of about 30 varieties mainly introduced from Australia at the Pomological Station, Coonoor, the following eight have been selected as the most promising for commercial cultivation on the Nilgiris.

1. IRISH PEACH:—Fruit small, flat and slightly ridged, brilliantly scarlet coloured with yellow patches; flesh soft, tends to be mealy when well-ripened, aromatic and sweet. A mid-season variety, prized for its prolific bearing and attractiveness but is ranked only among the moderately good apples of the region. A moderately vigorous tree, semi-spreading, with terminal bearing habit, possibly responsive to light pruning. Blooms in three distinct stages, main crop being from the first, while the second and third account for about 15 and 2 per cent of the crop respectively. The variety is immune to woolly aphis.

2. SIGNE TILLISCH:—Fruit large, flattish and even, rose tinted on pale green background; flesh crisp, juicy and sweet. A late dessert variety valued for the keeping quality of its fruit, which can be stored even for two months after harvest. A moderately vigorous tree with erect habit. It is a spur bearer and is resistant

to the woolly aphis, but susceptible to "pink disease," caused by the fungus, *Corticium salmonicolor*, but the trees can be kept clean by timely sprayings with Bordeaux mixture.

3. CARRINGTON:—Fruit medium, oblong, rich red in colour; juicy and sweet when ripe; best eaten from the tree but will keep a month if gathered before it ripens. A mid-season dessert variety, in demand for its very attractive fruits and regular bearing habit. It is a dwarf and erect type, bearing fruits on spurs and non-spurs in about equal proportions. It is immune to woolly aphis.

4. ZOUCHE'S PIPPIN:—Fruit small, flat, pale yellow with broad crimson patches; flesh mealy and sweet when ripe; does not keep well and should be left on the tree as long as possible; else it will shrivel in the store. A dessert variety valued for its earliness in season. It is a dwarf type, upright in habit and is a spur bearer. It is also immune to woolly aphis.

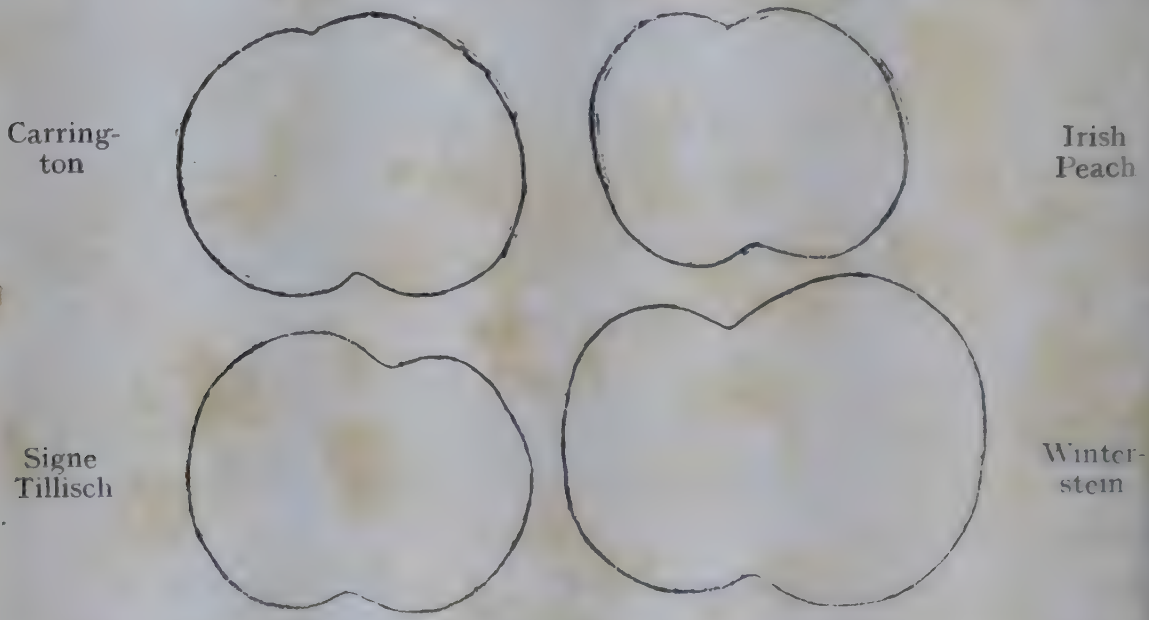

Fig. 84. Specimens of commercial apples from Coonoor.

5. WINTERSTEIN:—Fruit large, oblong, dull ashy red in colour over a pale yellow base; flesh crisp, juicy and sweet when ripe; is easily bruised and does not keep well. A mid-season dessert variety, popular for its relatively rapid growth in the orchard. A vigorous grower, and is upright in habit. Blooms in two waves, the first being the most important accounting for nearly 95 per cen of the crop. A pronounced non-spur bearer, which responds to a annual tipping of lateral and leader shoots of the past season' growth. It is susceptible to woolly aphis, but by root-grafting or the immune Merton stocks this variety may be successfully grown.

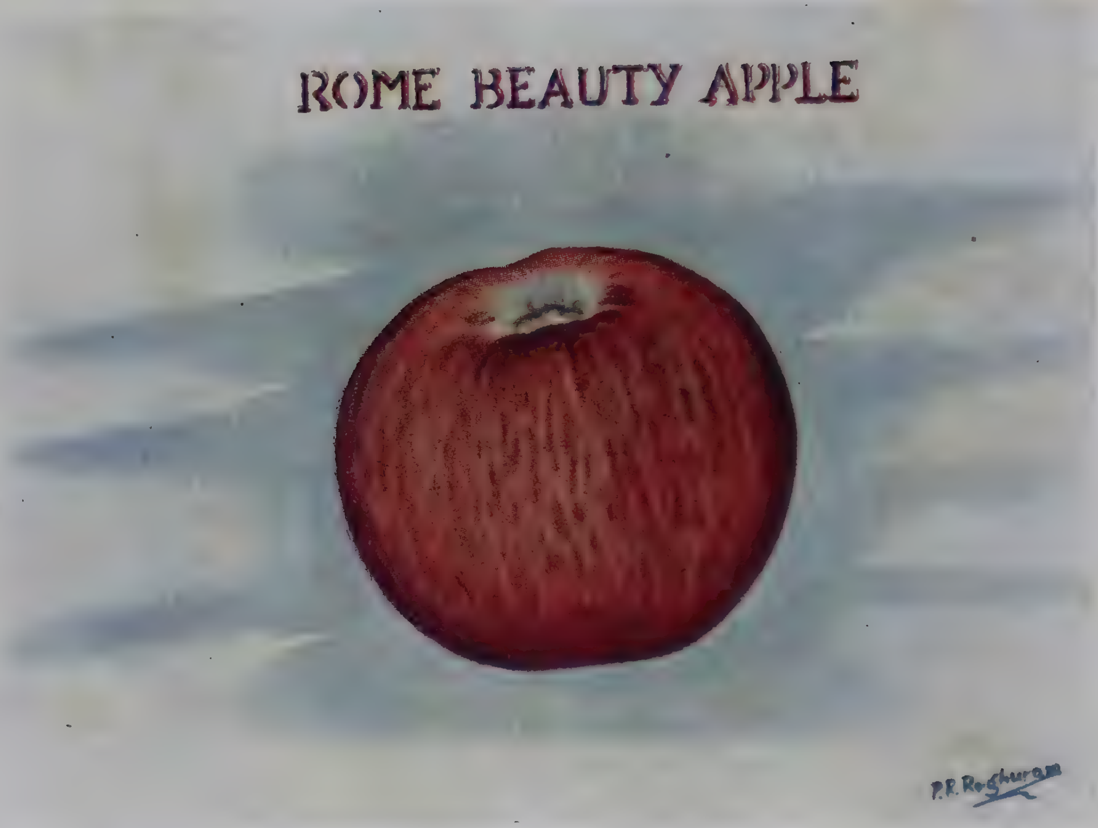
ROME BEAUTY APPLE
P.R. Raghuram

PLATE V

(Courtesy of Eco. Botanist, Bangalore)

(To face page 321)

6. Rome Beauty:—Fruit medium, oblong, with large dull red streaks; flesh crisp, sweet and tasty when ripe; keeps well. A late dessert variety popular for its earliness in attaining bearing age and its suitability for training as cordons. A dwarf type with weeping habit, it bears fruits on spurs and non-spurs roughly in the proportion of 20 to 80 per cent, possibly responsive to moderate pruning of past season's shoots. Very susceptible to woolly aphis, but by root-grafting as in the case of Winterstein, it still may be successfully grown.

7. Allsop's Early:—Fruit small, round, slightly tapering at the distal end; red and yellow blend in colour; flesh crisp, juicy and sub-acid; cooks well. A culinary variety in demand for its earliness in season. A moderately vigorous grower with sprawling habit. Bears almost equally on spurs and non-spurs. It is immune to woolly aphis and is subject to rotting of fruits, which may be prevented by regular sprayings with Bordeaux mixture.

8. Edward VII:—Fruit large, round and even, with dull red-coloured splashes on greenish yellow base; flesh crisp, meaty with little core, sub-acid; fruits must be gathered in good time or they start cracking. A mid-season culinary variety, very popular for its large fruit and cooking qualities. It is a dwarf type with compact habit, and is a typical spur bearer that may be pruned lightly. It blooms in two waves like the Winterstein, but both the blooms are equally important in the production of the annual crop. Susceptible to woolly aphis, and as with Rome Beauty and Winterstein, root-grafting on the immune Merton stocks is recommended for successful cultivation.

In Mysore State, it is reported that nearly seventy varieties have been tried, but none has proved as suitable for the region as the Rome Beauty.

PROPAGATION AND ROOTSTOCK

Till about the year 1942 the only methods of propagation of apple were the whip and the whip-and-tongue grafting on crab rootstock. This is a wild apple generally raised from seed and rather slow growing in seed beds. On the Nilgiris the crab does not, however, occur in the wild state as in the natural apple growing countries and therefore, the rootstock material has to be collected largely by lifting out the root suckers from the plantations stocked with introduced trees. These root suckers are transplanted into nursery beds and are grafted over after they become established. Experience has shown that the crab is susceptible to woolly aphis, and the apples worked on it do not grow very vigorously at Coonoor. Early in the forties, standard clonal stocks of the Mallings and Mertons were introduced to Coonoor for a trial. The former have been evolved at the East Malling Research Station, England and contain several types numbered I to XVI. Besides producing grafts or budlings of a more uniform character than on the crab, they are also useful in securing trees of the required vigour in the orchard. For instance, Malling I is classed as a stock producing moderately vigorous orchard trees of the scions worked on it, while Malling XIII and Malling IX are known to produce very vigorous and dwarfing scion trees respectively. All the Mallings tried at Coonoor, however, were found to be susceptible to woolly aphis, besides being shy in sucker production in layering beds. The Mertons were evolved at the John Innes Horticultural Station in England by crossing between Malling II and Northern Spy, which is reputed to be highly resistant to woolly aphis. Merton stock Nos. 778, 779, 789 and 793 have maintained their reputation for resistance to the woolly aphis at Coonoor also, and further have been found to produce a larger number of layers per plant, numbering up to 3.0 in Merton 778 per year, as against the maximum mean of 0.5 in Malling No. I and XIII in 1946 and 1945 respectively. That the Mertons provide the most promising rootstock material for the apple is therefore clear. In Mysore State, Northern spy continues to be the most popular rootstock for the apple, because of its resistance to the woolly aphis, although it has the defect of dwarfing the scion trees.

Among the various methods of propagation of the apples, bench-grafting has been favoured in some countries, as by this the stem piece of the rootstock which is also a centre of infestation by the woolly aphis is eliminated and thereby a higher degree of resistance to the pest is believed to be imparted. This method has been successfully tried at Coonoor, and has given a successful "take" up to 90 per cent. with Irish Peach scion variety. The plants intended to be used as rootstocks are lifted out in October to December and are whip or whip-and-tongue grafted by using only the root piece near the collar of the rootstock. The grafts are left for callusing in a sphagnum moss-lined box for about a month, after which the grafts are set out in the open beds. Side grafting of the apple also has produced a high "take" of 80 per cent in 1942-'43, while shield budding as tried in several seasons with and without a piece of wood attached to the bud-shield, as well as flute budding, have registered a maximum successful " take " of only about 26 and 20 per cent. respectively. From the view-point of success, there is no doubt that whip-and-tongue grafting has established its superiority over all the other methods at Coonoor, producing a hundred per cent " take " with several scion varieties. There does not appear to be any material difference between whip and whip-and-tongue methods, excepting that whip is easier to perform and is therefore to be preferred to whip-and-tongue. Equally high success by both methods has been obtained when worked in December and March. Saddle grafting has also been tried, but was found not very promising on a commercial scale.

Planting :—The planting of all fruit trees on the hills can be done from July to January. From the observations on the tree size in orchards, it would appear that a spacing of ten feet from tree to tree will be adequate for varieties like Zouche's Pippin and Signe Tillisch, 12 feet for Carrington and Allsop's Early and 15 feet for Irish Peach. These suggestions have to be modified according to the type of rootstock used, the dwarfing ones requiring less space than the vigorous ones.

The majority of apples are known to be incapable of setting a good crop of fruits with their own pollen. Establishment of blocks of a single variety in such cases is therefore to be discouraged. Some of the apple varieties also are known to be imperfect pollinators, since they have large proportions of defective pollen, and these also render the planting of such varieties together, or as pollinators, undesirable. The occurrence of abnormal fruit shedding as well as the production of misshapen fruits have also been traced in other lands to be due to imperfect fertilization. All the above facts apply also to pears. Fortunately, one of the best varieties grown in Coonoor, viz., Irish Peach is found to be a perfect pollinator and can be safely planted in solid blocks by itself, but it is difficult to say if the same recommendation can apply to other varieties. Raising of mixed apple plantations of such varieties is therefore a safe procedure, at least till more is known about their varietal peculiarities.

GROVE CULTURE

Apple is grown both as an irrigated and rainfed crop in South India, though in the latter case also irrigation to the trees becomes necessary in the first year of planting the trees, particularly in the dry summer season. The need for irrigation and its frequency are largely determined by the quantity and distribution of rainfall and, therefore, it is difficult to generalise on these subjects.

In the case of manuring of the apple too, definite suggestions are not possible at the present stage of the work on this fruit. However, the usual practice on the South Indian hills is to apply a mixture containing one bushel of cattle manure, one-fourth pound of each ammonium sulphate and superphosphate per tree when less than about three-years-old, with double the above quantity of each for trees between three and ten years of age. After this age, the annual applications consist of three bushels of cattle manure and one pound in each of ammonium sulphate and superphosphate per tree. Manuring is done usually in July.

The raising of intercrops is generally not possible in the apple groves, since the trees are spaced closely to each other. However, growing of a green manure crop like *Tephrosia vogelli* is recommended at least two or three times in the life of the apple orchard after some interval. This plant grows well if sown in the rainy season, and it can be uprooted just when it reaches the stage of setting seed, and buried in the alleys as green manure. Profuse irrigations to the green manured area are essential, if the organic matter is not decomposed by the rains occurring soon after it is incorporated in the soil.

Frequent and deep culture of the soil on the hills is neither feasible nor desirable, because of the risk of soil washing. One hoeing or hand weeding during a dry spell in August and another in the beginning of summer are considered adequate for the crop on the Nilgiris. On the plains at Bangalore one or two more cultivations are possible and may be done to prevent excess of weed growth. After about October weed growth may be permitted in the apple groves on the hills, removing only those which run into flower. This helps to draw moisture from the soil and thus induce the trees to go dormant.

In Bangalore the practice of enforcing the trees to produce two crops in a year is done through root pruning the trees, once in January-February and again in August-September. About fortnight before the operation, water is withheld to the trees. The actual treatment of root pruning consists of digging the soil to depth of about six inches within the drip of leaves around the stem. In about two days the leaves begin to wither and drop off, after which the pits are refilled first, with a thin layer of sand and then with soil mixed with manure. The trees are then watered copiously. During the following two or three weeks, the treated trees blossom, and the fruits become ready for harvest in five or six months.

TRAINING AND PRUNING

Commercially the apple is grown as a tree fruit and trained to a modified leader system, but in home gardens it also enjoys some popularity as cordons or espaliers. The cordon-trained apple, wherein two main branches of a tree are retained and trained along a horizontal wire on either side of the stem, has been found to offer some possibilities at Coonoor. Rome Beauty trees trained by this method have yielded 11 fruits each in the second year of planting, thus indicating the trees' precocious nature induced by this training. Apart from building the frame-work to suit this type of training, the annual pruning of these cordons consists of removal of crossing or crowded secondary growths, accompanied by thinning of laterals and shortening back of long ones to about three-fourths of their length. All growths less than about eight inches in length need not be pruned back.

It has to be remembered that a bulk of the crop on the apple is borne either on spurs or on one-year-old wood. If the tree is growing satisfactorily, it will produce new growth annually, and these in their second year will produce flower buds in the varieties which are non-spur bearers. Indiscriminate cutting back of new growths every year will therefore tend to reduce crop size, while no pruning or failure to thin the new growth may reduce the production of new growth in subsequent years, thereby leading to alternate bearing. Careful thinning of congested parts together with cutting back of long growths to encourage spur growth, are therefore the usual practices adopted in the pruning of the apple. The alternate bearing is specially noticeable among the non-spur bearers, since the spurs on varieties from South India are able to produce fruit buds fairly regularly every year when once they are formed, mostly from or near the point of union of the fruit stalk. It is easy to distinguish the fertile wood from the rest in apples, since the former will have more plump and swollen buds in the dormant season than on the barren wood.

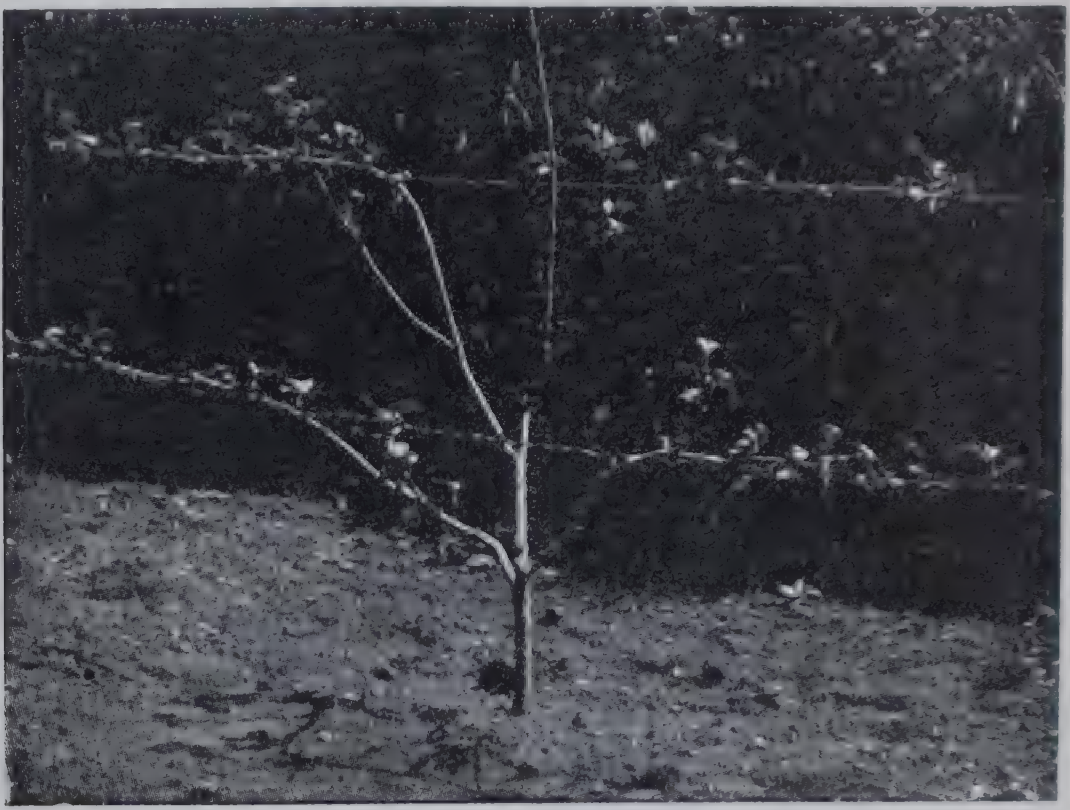

Fig. 85. Dwarf apple on wires

Among the varieties at Coonoor, Winterstein is a mainly non-spur bearer. Irish Peach is also a terminal non-spur bearer, and therefore does not respond to severe restriction of growth or for training as cordons, for which spur bearers like Rome Beauty are more suited.

On the basis of a pruning trial conducted from 1944-'47 it has been established at Coonoor that, with a mainly non-spur bearer like the Winterstein, an annual tipping of lateral and leader shoots increases flush and fruit production by a little over 14 and 13 per cent. respectively over unpruned trees. With spur-bearers, only the excess of wood and crossing limbs need be removed.

The pruning of apples begins at Coonoor in December commencing with earlier flowering varieties like Allsop's Early and Zouche's Pippin. The mid-season varieties like Irish Peach, Carrington and Signe Tillisch are best pruned in January.

Both in the pre-bearing stage as well as afterwards, heavy pruning should not be done with slow growing varieties, as they seem to resent such treatment. Trees which tend to produce long branches bearing crop at the ends, require on the other hand, severe cutting back to regulate shape.

All pruned shoots may be burned to avoid spread of diseases and pests. A spraying with lime solution (1 lb. of quick lime freshy slaked to 10 gallons of water) is recommended to the trees soon after pruning as a prophylactic measure. A thorough cleaning of the grove to remove all weeds is also suggested at the same time, so as to prevent the weeds from robbing of the soil moisture in the ensuing summer.

Fruit thinning :—It is to be expected that with a crop like the apple which is outside its natural home and is therefore given to produce crops below the standard size, any thinning of fruit is likely to be deleterious. This surmise has been confirmed from actual trials carried out from 1944-'46 with the most prolific Irish Peach at Coonoor. The results show that fruit thinning leads to a severe restriction in crop size, the loss ranging from 11 per cent in the lighter forms of thinning to as much as 83.7 per cent in more severe forms. The increase in individual fruit size is slight and does not compensate the large crop reduction. The practice of fruit thinning is therefore not to be recommended under Coonoor conditions for the apple.

Cropping :—Apples flower at Coonoor mainly in the month of March, particularly in varieties like Zouche's Pippin, Allsop's Early, Irish Peach and Carrington. It was however noticed that certain varieties produced more than one crop of blossoms in 1943 at Coonoor. The earliest apple available at Coonoor is Allsop's Early, which is ready for harvest by the end of April. By the following month, Zouche's Pippin also can be gathered. Irish Peach follows in June, with Carrington, Rome Beauty and Signe Tillisch in July. In Bangalore two crops are regularly secured in a year, by such forcing methods as root pruning the trees in a severe form. Since the North Indian apples enter the South Indian markets from October to December, the summer crops of South Indian apples are able to command a good price.

The yields of individual trees at Coonoor have worked out to an average of 24 lbs. each on Allsop's Early and Irish Peach, 12 lbs. each on Signe Tillisch and Winterstein. The maximum tree yield with Irish Peach, however, has gone up to 52 lbs. in a year.

In Bangalore, it has been reported that a five-year-old tree yields 4 to 5 dozen fruits and that, a maximum of 363 fruits has been recorded on a nine-year-old tree of Rome Beauty. The December-January crop is found superior in quality and in size. From the tenth year, the crop declines and after the twelfth year the trees are grubbed out. The above stated figures are undoubtedly low as compared to the yields of even up to 1,000 lbs. per tree per year in Kashmir and Kulu Valley, even though the value of the fruit on an acre scale when planted very closely in the orchard cannot be minimised in a region like the South India far removed from the ideal apple zone.

The profitable life of the apple tree at Coonoor is believed to be about 25 years, at Bangalore only 12 years, while at Kashmir 60-year-old plantations are said to be common.

The apple should be picked carefully and not pulled off the trees. Each fruit is wrapped individually in paper and placed in a box, which is securely nailed for distant transport. The cooking apples may be harvested even before attaining full maturity.

To meet fancy trade for individual taste, it is customary to wrap the growing apple while still on the tree with banana strips or any such material, leaving a net-work of rind surface of the fruit unwrapped. These leave prominent markings on the fruit in the form or shape desired. Sometimes the name of the producer or of the variety is marked on the fruit by this means.

PESTS AND DISEASES

Pest :—

1. WOOLLY APHIS (*Eriosoma Lanigerum*) :—This is also known as American blight. Colonies of small insects infest the roots and stems of the trees, causing unsightly galls. The tree yields decline as a result, to an appreciable extent. Spraying with nicotine sulphate has been tried but with little benefit to control the root infestation. Insect predators are known to check the aphids, and one such parasite, *Aphelinus mali* has been introduced. Though it has been found to have a counteracting influence, it has not proved really effective in eradicating the pest. Use of resistant stocks as Northern Spy and Mertons and of scion varieties like Irish Peach, Zouche's Pippin, Carrington and Signe Tillisch are recommended to minimise the spread of the scourge.

PLATE VI. APPLE TREE IN BEARING IN S.INDIA
(Courtesy of Eco. Botanist, Bangalore)

(To face page 328)

2. SAN JOSE SCALE—(*Aspidiotus perniciosus*):—A notorious insect with a capacity to even wipe out certain fruit industries, this is one of the pests of the apple, plum and some other deciduous fruits most dreaded by growers. The affected trees succumb quickly. At present the destruction of affected trees seems to be the only solution. However, spraying with diesel oil or fish oil and rosin has been tried compulsorily in Kashmir, while the above with lime sulphur have been advocated in the Punjab. The scale spreads with nursery plants, and effective check in importation of the infested plants provides the best preventive measure.

3. ICERYA PURCHASII:—This is also another scale insect which infests a large number of crops on the hills, including the citrus. Like the San Jose it too spreads with plants, against which quarantine restrictions have been imposed.

4. PLANT LICE—(*Dilachrus Krishni*) :—Colonies of these insects suck the plant sap and cover the shoots. This is a minor pest, against which spraying with nicotine sulphate has been advocated.

Diseases :—

1. MILDEW—(*Oidium* sp.):—This causes whitish powdery growth on leaves and shoots. The damage is not heavy ; and the removal of diseased leaves and spraying with Bordeaux mixture are considered adequate.

2. DIE-BACK OR PINK DISEASE (*Corticium salmonicolor*):—Leaves and twigs of affected trees wither and dry up and pale pinkish incrustations are found on the stem. Pruning of dead and diseased parts and burning of the prunings as well as coating of cut wounds with an antiseptic are suggested.

3. COLLAR ROT :—This was originally believed to be due to *Sclerotuim rolfsii*, but is now found to be an yet unidentified species of fungi. The disease results in rotting of the root or stem around the collar and is reported as a serious disease in Bangalore. No successful remedy has yet been devised. Exposing of the stem collar and a part of the root by fixing around the stem burnt clay pots of about 18" diameter is widely practiced. Around the stem and roots within the pot, pure sand is thrown in, in place of the soil. Occasionally the exposed parts within the pot are also washed with Bordeaux mixture. These treatments are said to be fairly useful in checking the disease. Use of *Pyrus baccata* as a resistant

rootstock to the disease is being tried at Bangalore. Observations seem also to show there that Northern Spy is more susceptible than several others as a rootstock, but on the same rootstock, Rome Beauty and Red Astrachan are relatively less susceptible than other scions.

List of References

1. Javarayya, H.C.—Bi-Annual Cropping of Apple in Bangalore, Indian Journal of Horticulture, June, 1943.
2. Naik, K.C.—Short Notes on Hill Fruits, Villagers' Calendar & Guide, Madras, 1943.
3. Rao, U. Narasinga—Regional Peculiarities in Apple Production, Madras Agricultural Journal, Nov., 1948.
4. Naik, K.C and U. Narasinga Rao—Scheme for Improvement of Hill Fruits, Bull. Madras Ag. Dept., 1947.

2. PLUM (*Prunus salicina*)

The name *Prunus salicina* is applied to the group of plums popularly known as Japanese plums, while the European plums are called as *P. domestica.* Since only the former are found to thrive in South India, the present text is concerned only with that group. The Japanese plums have been found to be most prolific and very remunerative at elevations ranging from 4,500 to 5,500 feet in South India, but outside this range they are not dependable. Despite their suitability for commercial production in certain tracts, the plums are not as popular as the apples with the South Indian growers, mainly because of the fact that the former fruits are more perishable and enjoy a limited class of patrons among the consuming public. According to an estimate for 1942-'43, only about 2,000 plum trees were under cultivation in South India, with an estimated annual production of 50,000 lbs. of fresh fruit. There seems to be some scope for extending the production of plums on the hills of South India through a wider dissemination of the virtues of this fruit.

VARIETIES

The selected varieties on the basis of a trial of over 35 varieties of plums at the Pomological Station, Coonoor are listed and briefly described below.

1. GAVIOTA :—Fruit medium-sized and round, with attractive wine colour, fine ashy bloom and yellow flesh of good eating quality; a fancy fruit and dessert variety harvested at the end of May. It

is a moderately vigorous grower with compact habit. The trees bloom in the second week of February and are best planted in proximity to Hale, Czar or Combination.

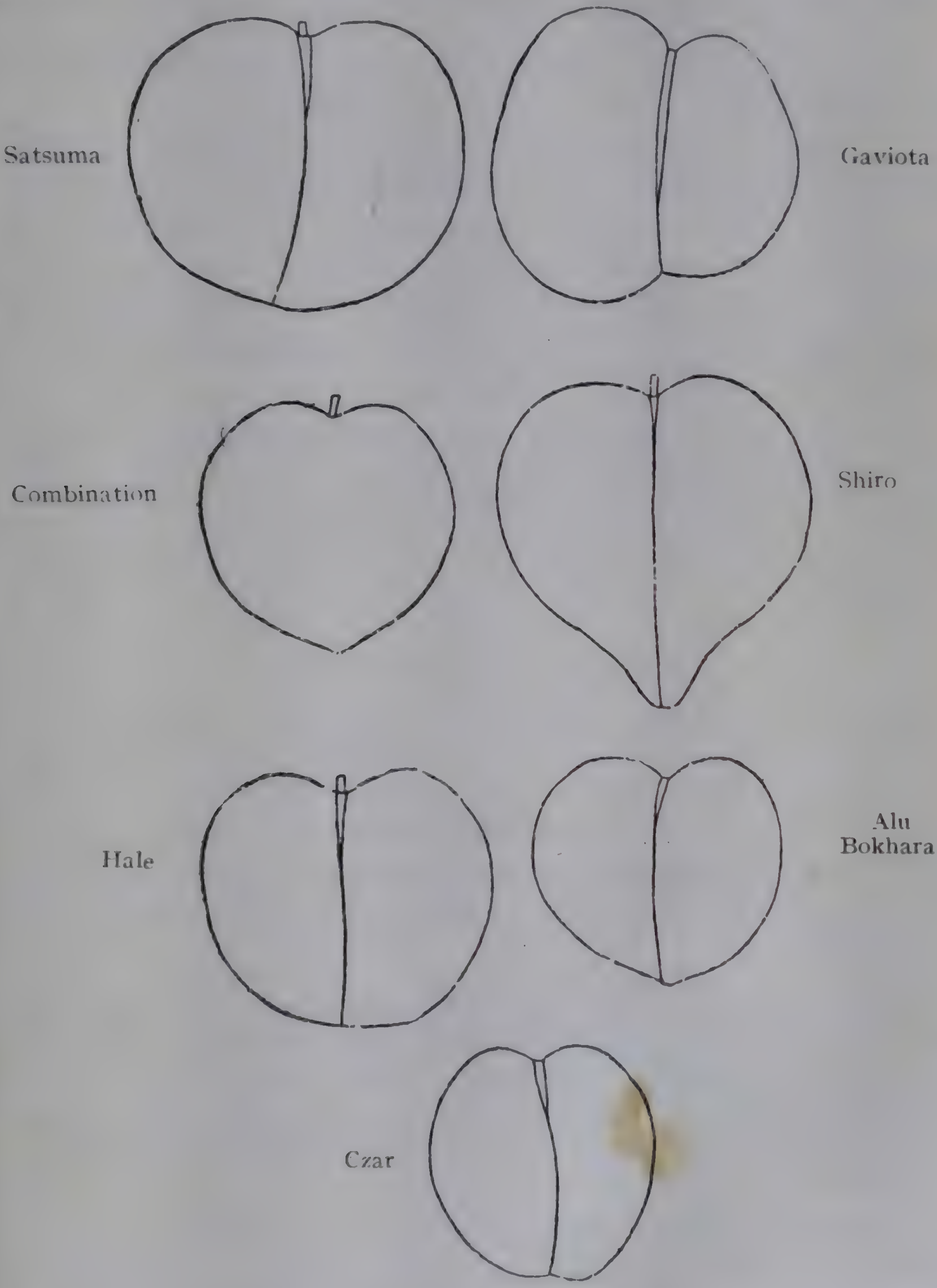
Satsuma
Gaviota
Combination
Shiro
Hale
Alu Bokhara
Czar

Fig. 86. Common plums grown in Coonoor.

2. SHIRO :—Fruit large, slightly tapering at the distal end with golden yellow colour and fine ashy bloom ; flesh yellow, very

juicy and of good eating quality. It is a superior dessert variety, harvested in the first week of June. Trees are vigorous growers with a spreading habit. They bloom in the third week of February and are also best planted in proximity to Hale, Czar or Combination.

3. ABUNDANCE :—Identical to Shiro in all respects except that the skin of the fruit is thinner in texture.

4. CZAR :—Fruit large, elongated, very attractive, purplish crimson in colour with ashy bloom when mature ; dark red flesh, rich aroma, juicy and of fine eating quality. It is a prized dessert variety, harvested in the first week of June. Trees are fairly vigorous growers with compact, upright habit, blooming in the third week of February. The variety is also best planted in proximity to Hale, Combination or Shiro.

5. KELSEY :—Fruit large with a prominent beak at the distal end ; amber coloured when fully ripe ; and of good eating quality. A fair dessert type, it is harvested in the third week of June. It is a vigorous grower and semi-erect in habit, blooming in the last week of February and is planted best in proximity to Hale, Shiro, or Satsuma.

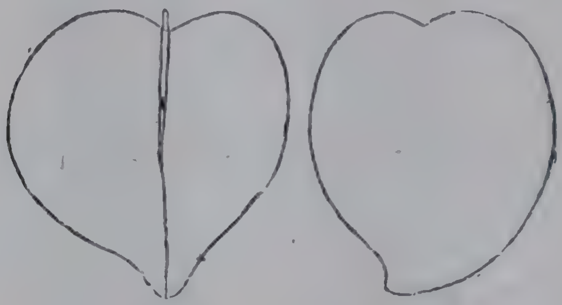

Fig. 87. Kelsey plum.

6. SATSUMA:—Fruit large with a cleavage line on one side and flattened at ends ; dull red colour with purplish red flesh and of good eating quality. A dessert variety, harvested in the third week of June, it is a vigorous grower with a spreading habit, blooming in the last week of February and planted best in proximity to Kelsey.

7. HALE :—Fruit medium, round, of dull red colour and of pale yellow flesh ; juicy and sweet when ripe. It is a very productive dual purpose variety, recommended for extensive commercial planting. It is a vigorous grower with a spreading habit, blooming in three or four successive waves from the second week

of February to the first week of March. It is best planted in proximity to Combination, Shiro or Czar.

8. **Rubio** :—Fruit medium, round, crimson in colour with red, juicy and subacid flesh, its tartness making it a favourite for culinary purposes. It is a prolific bearer and is very early in the season, being harvested in the last week of April. It is a vigorous grower with a semi-erect habit. The blooming is in the last week of January, and the trees are best planted in proximity to Alu Bokhara.

9. **Satsuma Seedling** :—This resembles Rubio in all essential respects, but the fruits are less tart when fully ripe.

10. **Alu Bokhara** :—Fruit medium to small, slightly elongated with yellow skin colour having red splashes ; flesh white, juicy and moderately sweet when fully ripe. A good stewing variety, valued for its prolific bearing and earliness in the season. It is harvested in the third week of May. A vigorous grower of semi-erect habit, it blooms in the second week of February and is planted best in proximity to Satsuma Seedling and Rubio.

PROPAGATION AND ROOTSTOCK

The plum is propagated at Coonoor almost entirely on year-old common peach seedling rootstocks by shield budding. An alternative method by flute budding has been tried at Coonoor with the hope that it would render possible the use of younger seedling rootstock, make it unnecessary to use of the bandage around the bud-joint, enable a larger number of bud-insertions in a given period by an individual, and thereby leading to an economy in nursery production cost. The results from 1943 to 1947 show that the success by both the methods of budding is almost the same, being in the neighbourhood of 90 per cent and that the optimum periods for the operation are December and January. During rainy periods, however, flute budding fails to produce as large a number of successful unions as shield budding ; and after union is effected the bud-sprouts by the former method seem to also grow more slowly. Cuttings of plums have been found difficult to root at Coonoor.

The common peach that is used as a rootstock for plum as well as for peach at Coonoor also goes by the name of country peach in South India. The latter name does not seem appropriate, as it is not indigenous to this country and is believed to have been originally introduced to the region from Australia. It is a hardy peach, precocious in bearing, producing a medium sized, clingstone fruit suited mainly for culinary purposes, and having little taste or flavour, and cannot, therefore, be deemed as a good dessert fruit. It has a flat peento shape and resembles the flat peach found in the plains of North India.

It has, however, been noticed that some plums like the Czar and Gaviota do not produce perfectly compatible bud-joints on the common peach. Attempts were made to try the budding of plums on *Prunus divericata*, but these showed that only the Combination variety made satisfactory scion growth on it, attaining a scion stem height of about seven and a half feet in the course of a little over four years after bud-insertion. Hale, Rubio and Alu Bokhara have been found to exhibit delayed incompatibility on this rootstock, leading to an almost complete cessation of scion growth after a time. For Czar, the Pershore has indicated to be a more satisfactory rootstock at Coonoor than the common peach. The suitability of *Prunus divericata*, Pershore and Early Jewel has been tested at Coonoor only on a limited scale, while the other rootstocks that are in use elsewhere such as the Myrobalan, Brompton and Mussel are yet to be tried.

PLANTING

The adequate orchard spacing for plums is believed to be only 12 feet with Gaviota, 15 feet with Czar, 18 to 20 feet with Kelsey, Rubio, Alu Bokhara and Satsuma Seedling, and 20 feet with Shiro, Abundance, Satsuma and Hale. November to January is preferred for the planting of trees in Coonoor, but the planting can also be done in July to December as in apples.

Observations at Coonoor as well as the reports of work don elsewhere have established that the productivity in plums is conditioned by the inherent character of the variety, particularly in regar to the capacity to set fruit with its own pollen or with that fror other varieties. In 1940-41, it was found that Cherry, Combination and Sultan set a better crop when cross-pollinated with Hal than when self-pollinated, the selfed trees recording a set of les than 2.5 per cent. as against over 18 per cent. set with Hale polle Combination, Kelsey, Jefferson, Czar and Gaviota are al reported to be self-sterile, and being scanty pollen producers ar therefore, ineffective pollenisers. Abundance on the other han is a good pollen producer, as also Hale and Alu Bokhara. Satsuma Seedling and Rubio are also reported to be completely self-fertile. The selection of the most effective pollinators for each of the commercially suitable plums under Coonoor conditions as well as of the self-compatible or self-fertile varieties that can be set out in solid blocks at Coonoor, are yet to be determined. Observations, however, show that Czar and Kelsey being mainly self-sterile cannot be planted together and by themselves in one block. To a lesser degree, Shiro, Gaviota and Abundance suffer from the same defect. On the other hand, Rubio, Satsuma Seedling, Alu Bokhara, Hale and Satsuma seem self-fertile and can be planted in solid blocks by themselves. Bees are known to help pollination in plums to a marked extent, and a couple of bee hives per acre are therefore very necessary in a plum plantation. It is also suggested that the varieties that flower at one time be planted together in the form of mixed orchards. On the basis of the blossoming period at Coonoor, Rubio, Alu Bokhara and Satsuma Seedling are classed under one group, while Hale, Shiro, Abundance, Gaviota, Czar, Kelsey and Satsuma are put under the second group. Since the varieties in either of the two groups may not all be compatible, it will be wise to plant representatives of more than two varieties under each group in any plantation.

TRAINING AND PRUNING

Proper pruning is of great importance in plums, since it determines largely the crop size and quality. Both the training and pruning methods have to be adapted to suit the natural habit of growth and the shape of each variety. A variety like Rubio for instance is a typical example of upright growing habit developing into vase shape, while the Hale is more spreading and conforms to the open-centred tree shape, thus requiring numerous branches and secondary growths to fill the head. In general, however, all Japanese plums may be said to run into an open-centered tree shape eventually, though the height at which the top spreads out may vary to a considerable extent between the varieties, depending upon the degree of angle made by the branches. Regulation of side branches by thinning out the congested areas and placing the rest all around the trunk at suitable intervals to conform to the natural tree habit, is the key-note of success in plum pruning during the early formative stage. In the relatively erect growing varieties like the Rubio, the top should be opened out to some extent, while in the more spreading varieties like Hale, the tree should be helped to grow a little upright, taking care in both cases not to resort to drastic cutting. The upright tree can be made to spread out a little by pruning to an outside bud or by making a leader of the second or third strong lateral. In the spreading tree, the pruning has to be to an inside bud or to a bud on the upper side of a horizontal leading lateral, in order to induce upright growth. Hard pruning is to be deprecated in either case, as this may produce stunted trees. Rao has recommended an open centre for all Japanese plums grown at Coonoor. He advocates the planting of an unbranched whip with a single clean stem, two and a half feet in height—the larger height for spreading types like Shiro, Abundance, Hale and Satsuma, less for semi-erect types as Rubio, Satsuma Seedling, Alu Bokhara and Kelsey, and least for erect types as Gaviota and Czar. In the second year of planting, the selection of four to six main scaffolding branches is made, which should be well placed all around the stem, and the rest are to be removed. The shoots which are retained are headed back to about three-fourths of their length. In the third year, two new shoots on each of the scaffold limbs are retained and these should point inwards or outwards according as the variety is spreading or erect in habit, and the rest of new shoots are to be removed. The former are also headed back to about three-fourths of their lengths. This procedure is to continue for two more years, taking care at the same periods to prevent congestion and the formation of weak crotches.

In the bearing trees of Japanese plums, the spurs are lateral and usually function for three to four years and sometimes even longer, depending on their vigour. The spurs being very short and producing fruit buds only laterally, it is inadvisable to shorten them. Besides the spurs, fruits are also borne on lateral shoots, having both leaf and blossom buds distributed along their lengths. These can be shortened, unlike the spurs, with some benefit. Another type of fruit bearing growth is the sprig, which is intermediate in length between the spur and the lateral and produces fruit buds only on the lower parts. These too cannot be shortened, since it leads to removal of all growing points, and consequently the lower flower buds may fail to set fruit. There is no foliage beyond such buds to draw the sap through the fruit buds and, therefore, the pruned sprigs may be starved to death.

To an extent, pruning has also to be varied according to the bearing and pollinating habit of the variety. In the case of a self-fertile and free-blooming variety like the Satsuma, heavy pruning is reported to be desirable but in self-incompatible Czar, only light pruning has been recommended on the ground that cross-pollination may be inadequate to obtain sufficiently good fruit set.

Summarising the pruning practices it may be stated that the laterals being mainly the spur producers, should be shortened for stimulating spur production, the length to be pruned depending upon the variety. A year after such pruning of a lateral for the first time, it may again be cut back as two year-old wood for the selection of the required number of spurs. Thinning out the multiple spurs on the laterals is also necessary for preventing congestion and to prevent over-bearing, and thereby to secure better sized fruit. Retention of yearling laterals beyond the fruit spurs is not recommended, since this may lead to the death of the spurs lower down, while the lateral is developing. The fruit will also be carried progressively away from the limbs as years roll on. To keep the fruit on young wood as near the limbs as possible, the laterals arising at the base of older spurs or near them should be employed for spur replacement. This is effected by shortening an old spur and thus to induce a new lateral near it to grow. It has to be remembered that the best fruit is produced on the laterals, sprigs and spurs directly off the main limbs, and the fruits from aged spurs are small. These are the recommendations based on the work and observations elsewhere, but are considered as applicable to the Japanese plums grown at Coonoor also.

Prior to 1941 a system called as "short" pruning, in which all the past season's shoots were cut hard back leading to a removal of about 75 per cent of such growth, was in vogue at Coonoor. The method appeared to be too drastic and was thought to have been responsible for a degree of tree dwarfing and for the progressive decline in tree yields to an extent. The trees were therefore brought under "long" pruning, wherein the pruning was restricted only to the removal of dead, diseased or crossing limbs and growths. The response to this switching over to a less severe pruning method was marked, resulting in an annual increase in yield ranging from 15 to 20 per cent. in Rubio, Satsuma Seedling and Alu Bokhara.

The beneficial effects of thinning the spurs has also been brought out from a trial at Coonoor, where spurs thinned to a spacing of six inches increased fruit yields by 8.6 per cent by weight and 10 per cent. by volume.

Rao has estimated that in Rubio, Satsuma Seedling and Alu Bokhara, 15 to 20 per cent. of the annual crop is carried by laterals of one year's growth, while in Shiro and Abundance, although the production of laterals is abundant, little fruit is produced on them directly. Again, with Gaviota, Kelsey, Satsuma, Hale and prune Splendour, the output of laterals is scanty unless stimulated by a severe heading back of older shoots. The lateral shoots are important since they give rise to fresh spurs or sprigs. If the laterals are numerous, thinning is suggested ; if few, they are best left alone. In either case, heading-back the laterals to leave a stub is harmful, excepting once in four or five years or when the trees are declining in yields. In such cases, an occasional heading back promotes new growth; on which fresh spurs and sprigs are formed in place of the dead and worn out ones below.

The pruning of varieties like Shiro, Abundance, Czar, Kelsey, Satsuma and Hale is usually done in February at Coonoor, while that of Rubio, Alu Bokhara and Satsuma Seedling is done in March.

Fruit thinning :—From 1943 to 1947 fruit thinning trials were carried out at Coonoor on the prolific Rubio ; and these have shown that thinning of fruits at the marble stage to leave a spacing of one inch between any two fruits, leads to an increase of individual fruit size by about 50 per cent. above the normal. The gross yields, however, were reduced by about 42 per cent. but this was compensated to some extent by nearly double the price that the larger fruits were able to secure. The other advantages associated with thinning were, shortening of the harvest period by nearly a fortnight due to relatively more uniform ripening of fruit on thinned trees, and the better colour of fruit on the same tree. In so far as Rubio is concerned, it is therefore clear that thinning is very desirable. More severe thinning by adopting a longer spacing between fruits, have not been found necessary. The removal of imperfect plums has to be attended to at the time of thinning operation.

Cropping :—Flowering in plums commences normally in December and may continue till March end in late varieties. Rains in January-February may interfere with pollination and fruit set, if received in excess. In 1943, towards the close of May a hailstorm occurrence at Coonoor also contributed to reduce the crop size by causing abnormal fruit shed, but fortunately such elemental depredations are rare in Coonoor. Harvest of early varieties like Satsuma Seedling and Rubio may commence towards the end of April, with those of mid-season plums like Alu Bokhara, Gaviota and Hale in May and of late varieties like Shiro, Czar, Satsuma and Abundance continuing till June. The yields vary to an extent between varieties and seasons, the mean in Rubio having been about 74 lbs. per tree in 1947 and as low as about 18 lbs. in 1946. In Hale the range from maximum and minimum tree yields was roughly 101 lbs. to 5 lbs. Alu Bokhara has recorded at Coonoor tree yields as high as about 87 lbs. Analyses of the yields from 1943 to 1947 show that there is neither any biennial bearing tendency in plums at Coonoor nor any definable rhythm in seasonal production. The varieties seem to respond in almost a similar degree to seasonal factors as reflected by their yields.

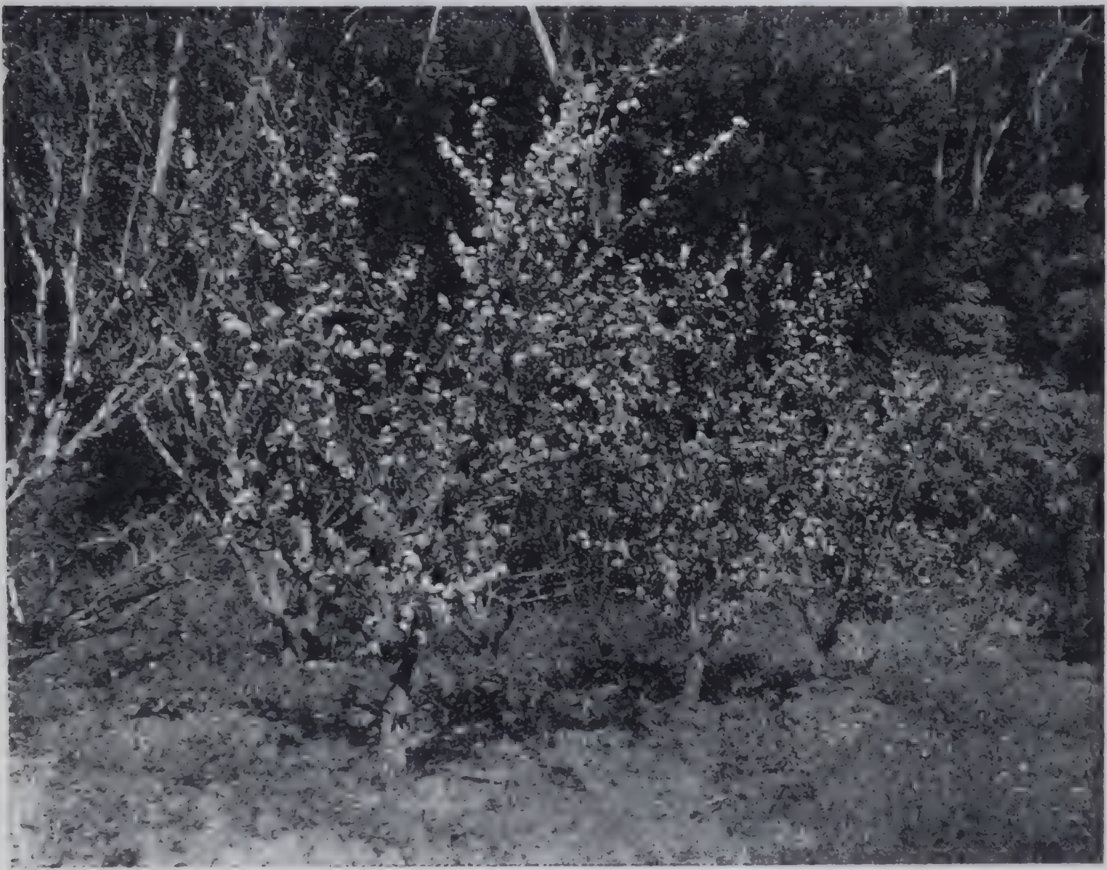

Fig. 88. Alu Bokhara plum in blossom.

Plums (*Prunus domestica*) which bear sweet fruits and are suited for drying without the removal of the pits are known as prunes. The Splendour has proved to be the best variety tried at Coonoor out of the four introduced, including Sugar, California d'Agen and Giant. The dried Splendour fruits were found to be of good quality to be sold as prunes. Prune Splendour produces small sized fruits, with a distinct cleavage line on one side. The fruits are dull reddish purple in colour and sweet with a rich flavour and tough skin. The variety flowers in March and fruits ripen at the end of June. The damsons (*Prunus insititia*) have not been tried nor are grown at Coonoor.

PESTS AND DISEASES

Pests :—

1. FRUIT FLY—(*Dacus incissus*) :—The maggots of this insect bore into the fruits of plums and peaches and make them inedible. Plum Satsuma is particularly susceptible to this pest. The remedy is the same as stated for the pest under mango.

2. SAN JOSE SCALE—(*Aspidiotus perniciosus*) :—This pest has been dealt with under apple separately, and causes similar damage to plums and peaches also.

Diseases :—

No disease of any major importance has occurred on the Nilgiris.

List of References

1. Naik, K.C.—Fruit Personalities—Plum, *Mezhichelram* (in Tamil), Madras, November, 1945.
2. ,, —Short Notes on Hill Fruits—Villagers' Calendar & Guide, Madras, 1943.
3. Rao Narasinga, U.—Studies in Plum Production on the Nilgiris—The Madras Ag. Journal, September, 1947.
4. Naik, K.C. and U. Narasinga Rao—Scheme for Improvement of Hill Fruits—Bull. Madras Dept. of Agri., 1947.

3. **PEAR** *(Pyrus Communis)*

Although some hardy pear varieties grow and crop well in South India in the same situations where plums thrive, the choice-fruiting or superior pears are found to be more at home on slightly higher elevations as those between 5,500 to 7,000 feet in the region, such as in and around Ootacamund. Compared with the apple and plum, the pear is more widely grown in South India and is more popular among the general public. Its better keeping quality than the plum, combined with its relatively cheaper sale value than the apple are perhaps responsible for its wider appeal. According to the estimates of the Marketing Section, Madras, about 710 acres were under pears in 1942-'43, of which 557 acres were of "country" pears and 153 acres were under "English" pears. The estimated production of fruits in that year was in the neighbourhood of 6,000 tons.

VARIETIES

Over 20 varieties have been tried at Coonoor Pomological Station, among which only the Kieffer has so far proved to be promising and suited for commercial cultivation. Three other superior varieties are, however, found in orchards around Ootacamund. All these as well as the so-called "country" pear are briefly described below.

1. Kieffer:—Fruit large, pyriform but with different shapes on the same tree; yellow when fully ripe; flesh soft, slightly gritty, very juicy and sweet: a very prolific variety maturing in September: a vigorous grower, erect in habit: blooms in March-April.

2. Beurre Hardy:—Fruit large, uneven in outline, greenish yellow with patches of rough reddish colour; flesh tender, very juicy, and of good eating quality: a hardy and vigorous grower and of semi-erect habit: a regular cropper with fruits maturing in mid-June.

3. Louis Bon of Jersey :—Fruit medium, smooth, yellowish green with dark red flush and prominent dots of the same colour; flesh tender, melting and of fine eating quality: a sturdy little tree noted for its regularity in bearing habit, erect: matures in mid-June.

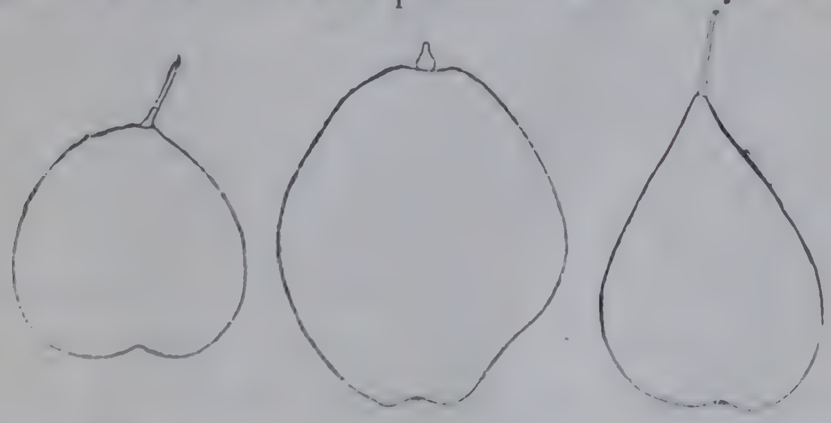
Louis Bon of Jersey Kieffer Beurre Giffard

Fig. 89. Common pears grown on the Nilgiris.

4. An Unnamed Variety :—Fruit small with a distinct bulge at the distal end; dull green with a yellow-tinted background; flesh yellowish, fine-grained and buttery with fine eating quality: a slender tree with somewhat weeping habit: matures in early June.

5. Stock Pear :—This is the pear in general use as rootstocks for cultivated pears and is popularly known as "country" pear. It is not indigenous to the country, though found in semi-wild state on the hills. It is a vigorous grower, bearing heavy crops annually. Fruits are large, flesh full of "grit" cells, and are fit only for culinary purposes.

PROPAGATION AND ROOTSTOCK

The common method of raising pear on the Nilgiris is by grafting by the whip-and-tongue method on rooted cuttings of stock pear. The stock pear, however, does not root easily at Coonoor, the success being rarely over 30 per cent. Marked success in increasing the rooting percentage of stock pear cuttings was achieved in 1946 at Coonoor by adopting such devices as slitting the cuttings at the base and smearing their tops with cowdung layer. The Kieffer and China pear (*Pyrus Chinensis*) also failed to root by cuttings. Although the Kieffer resembles the stock pear in several morphological characters, the differential rooting capacity of cuttings serves to bring out the distinct differences between these two varieties.

The whip-and-tongue grafting of pears on stock pear is easy and produces at Coonoor an almost hundred per cent. "take." The grafts on this rootstock also shape well and exhibit good orchard performance. On the other hand, the quince is well-known to be a dwarfing rootstock for pears ; and at Coonoor also incompatible stionic unions were the feature when pears were raised on it, even though the "take" was as high as 100 per cent. *Pyrus pashia* as a rootstock seems to be of possibilities, as grafts on it have so far been found very satisfactory in regard to orchard performance.

Some trials on top-working of superior pears on the unthrifty China pear by cleft and whip grafting have shown that, this is an easy and successful means of converting the useless trees into profitable ones. Seven top-worked Kieffer trees in 1944 have produced rapid extension growth on the scions, recording a mean shoot length of nearly six feet in the course of three years.

Shield budding of pear is possible, but has given a lower "take" at Coonoor than whip or whip-and-tongue grafting, the former being not more than 48 per cent.

Planting:—The pears are planted mainly in January at Coonoor with a spacing of 20 to 25 feet in the orchard. As in plums, interplanting of varieties is essential to facilitate cross-pollination. Unlike the plums, however, there is little variation between the pear varieties in regard to the amount of pollen produced, it being generally abundant. The provision of pollenisers in the orchard is therefore necessitated mainly by the self-sterility of certain varieties, although in this respect it has been reported that the degree of self-sterility of a given variety is influenced by climatic conditions. Among the several varieties tried at Coonoor, Jargonelle is not only a non-promising commercial variety but has also been reported to be a defective pollinating variety, while Williams and Beurre Giffard are said to be suitable as pollinators. Kieffer is reported to be self-sterile on some situations. Since it has been also reported that even the self-fertile varieties are likely to be benefited by cross-pollination, the planting of two or more varieties together in an orchard becomes very necessary.

Training and Pruning :—Pear is usually trained to a vase form. With vigorous, upright growing varieties, it seems necessary to head back the young tree fairly low at the time of planting and to cut back the shoots thereafter always to outside buds, so as to foster a spreading top. The pruning of the pear is not dissimilar to that discussed for the apple, varying of course according to the bearing habit of varieties. The pruning is done in December-January. Since pear is a slow grower and is late in attaining the bearing age, some special methods of training have been suggested to induce early bearing. One of these is the Caldwell system, by which the shoots are bent down to give almost the shape of an umbrella to the tree. This system was tried at Coonoor, but with no sign of success. Beurre Giffard trees of about five years of age when brought under the system failed to yield any crop even in the fifth year of the initiation of the new method of training.

Thinning :—Except in Kieffer and stock pear, fruit thinning may be of no value under South Indian conditions, since the yields are not such as to be classed as heavy. In the case of the two varieties mentioned above also, thinning may be neither economic nor desirable, as the fruit size even in unthinned trees is not small and the sale value of stock pear is not high. Where large size of individual fruits is aimed at, light thinning may be done; but while doing so it is well to remember that there is no advantage in separating the doubles. Such fruits may be removed altogether if there are enough singles on the tree.

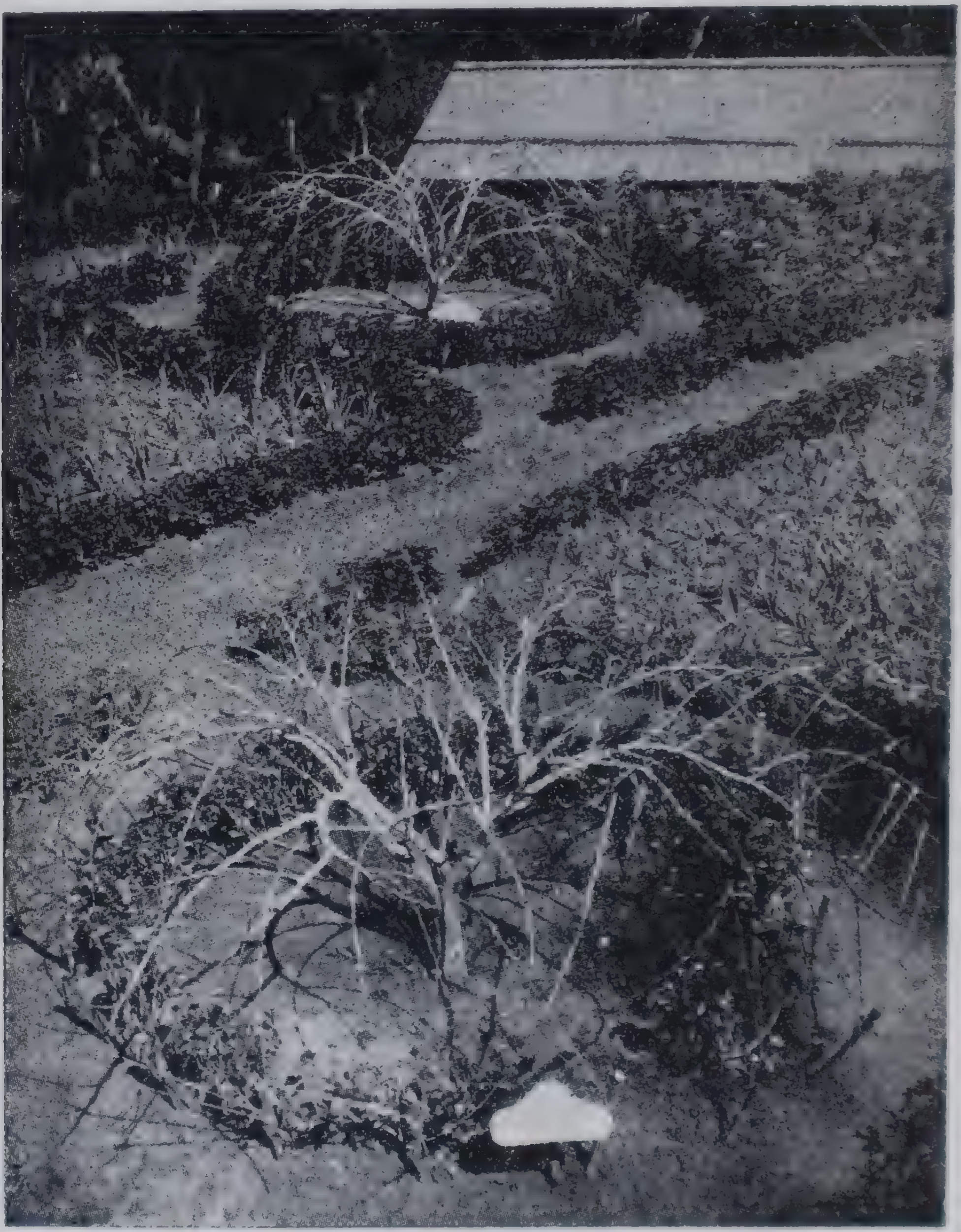

Fig. 90. Pears trained to Caldwell system.

Grove culture :—Because of the slow growing habit of the trees, the pear orchard is suited for intensive intercropping either with vegetables or fruits like Cape gooseberry, strawberry or tree tomato.

Cropping :—Trees flower from January to March at Coonoor, and fruits are ready for harvest from May to September. The first crop in the orchard is available for harvest only after the seventh or eighth year of planting.

The fruits should be picked only when they show a tendency to part easily from the spur on raising the fruit gently up. The picked fruits have to be ripened by packing them in tight closed boxes or in closed drawers of a table or almirah, and should not be exposed on shelves as is done with the apples. If allowed to be tree-ripe, several fruits develop soft cores and a mushy flesh. Since the quality of fruit depends much on the stage of maturity when it is picked, the above stated advice on gathering the fruits only when the stem snaps at the time of lifting the fruit and when a slight change in ground colour occurs, requires to be carefully followed. When kept in a closed chamber or box, mature Keiffer pears ripen in about a fortnight, developing a golden yellow colour and becoming soft and delicious. As stated already, September is the usual period when Keiffer is harvested at Coonoor.

The mean yield of Keiffer at Coonoor has been found to be about 70 lbs. of fruit valued at Rs. 8-8-0 in 1946. The stock pear yields far heavier crops, though fetching less value.

PESTS AND DISEASES

Pests :—Excepting the San Jose Scale pest discussed under apple, no major pest has been noticed in Coonoor.

Diseases :—The pear has also been remarkably free of any serious diseases at Coonoor.

List of References

1. Naik, K. C.—Fruit Personalities—Pear, *Mezhichelvam* (In Tamil), Madras, May, 1946.
2. ,, Short Notes on Hill Fruits—Villagers' Calendar & Guide, Madras, 1943.

4. PEACH (*Prunus persica*)

The peach grows under more or less the same climatic conditions as the plum in South India, except that it has certain hardy varieties which are adaptable to lower elevations, and some more which are at home on higher elevations. It is therefore a fruit with a much wider range of adaptability than the plum, though yielding less crop in any one of these varied environments in South India. Although some stray peach trees are found on the plains such as at Coimbatore or Bangalore, such trees are very poor yielders, and possess no commercial significance. The varieties that thrive on elevations exceeding about 6,000 feet in South India are also few to be reckoned as of great importance. Generally speaking, that part of South India lying between 4,500 and 6,000 feet elevations may be deemed to provide the most favourable conditions for the peach.

No definite statistics on peach acreage are available, partly because this fruit is rarely grown on an orchard scale in this part of the country. An estimated annual production of 31,800 lbs. of fruit is reported by the Madras Marketing Section for 1942-'43.

VARIETIES

Even in the most favoured zones in South India, only two out of about 20 varieties tried, have been found to be of commercial value, these being Killikrankie and Shanghai Seedling. These and two other varieties of promise located in and around Ootacamund and Kotagiri are described briefly below.

1. KILLIKRANKIE :—Fruits medium to small, pale yellow in colour with a red tinge at the stalk end ; flesh pale yellow, tender, moderately sweet and a clingstone : a very early variety, hardy and self-fertile : a moderate grower and of erect habit: blooms twice-first in December and again in January.

2. SHANGHAI SEEDLING :—Fruit large, yellow with red marks and pale flesh ; flesh yellow ; reddish near stone, melting, juicy, moderately sweet and a clingstone ; a late variety fancied for its large and attractive fruits : a weak grower, semi-erect in habit : blooms early in March.

3. RED SHANGHAI :—Fruit large, pale-yellow with red marks and pale flesh ; flesh very tender, red at stone ; best gathered a few days before ripe ; a clingstone variety much prized in the Ootacamund market.

4. NOT YET NAMED :—Fruit small, bright yellow with light red cheek ; flesh white, melting, sweet and juicy : a moderately vigorous tree of semi-erect habit and a regular cropper.

At Hessarghatta in Mysore State, trial of varieties obtained from parts of North India have all proved fruitless and only the flat country peach is found to thrive. This produces two crops, once in December and again in May.

PROPAGATION AND ROOTSTOCK

The problems in propagation of peach are not dissimilar to those described under plum. In both cases, the common peach seedling is employed as the rootstock. This has proved suitable for superior peach scion varieties in respect of "take," compatibility and orchard performance, and is therefore now in general use. A prominent defect of this rootstock, however, is the low germination capacity of its seeds, which rarely exceeds 10 per cent. A trial to improve the germination is under way at Coonoor. The optimum season for budding peach has been determined under Coonoor conditions, and is now known to be January and March. Between the shield and flute budding methods, the former is to be preferred, in view of the larger "take" secured by it, which in some seasons is as high as 100 per cent. In Bangalore grafting of the peach on plum was common, but now layering is largely practised with the former, as also with the pear and occasionally with the plum too.

Planting :—Like other hill fruits, peach is generally planted at Coonoor from July to January. The usual spacing is 15 feet both for Killikrankie and for Shanghai Seedling. Being a precocious tree, the peach can well be planted as fillers in a pear orchard, in which case they have to be removed after about 10 to 12 years when the pears attain satisfactory bearing age.

TRAINING AND PRUNING

Although the peach is generally trained to a vase shaped tree, recent work at Coonoor has shown that it is very suitable for growing as cordons. In this form they may be grown in orchard boundaries as well as in home gardens and present an attractive feature especially when in bloom or fruit. The pruning of bearing peach trees consists of annual shortening of the growths to force out new wood, upon which alone the fruit is borne. If left unpruned, the lower shoots dwindle and fruit is consequently pushed aloft on bare branches. The trees may also become full of hard and brittle bark and the naked limbs may be liable to be sun-burnt causing gum exudation and covered with lichens and moss. The vase form of training is useful in providing continuous leaders. In varieties which tend to bear fruit near the junctions with large branches, cutting back of fruit laterals hard, is necessary. With others, the branch itself may be cut back to produce new fruit wood abundantly. Such pruning becomes all the more necessary as the trees age. Observations at Coonoor have shown that shoots of above eleven inches in length of the past season's growth form fruitful wood. It seems best to tip such long growths lightly and prune shorter growths harder back. Sprigs and spurs are of little value in producing crop on peach, unlike in plums. All barren and old wood as well the diseased and crossing growths may also be removed at the time of pruning.

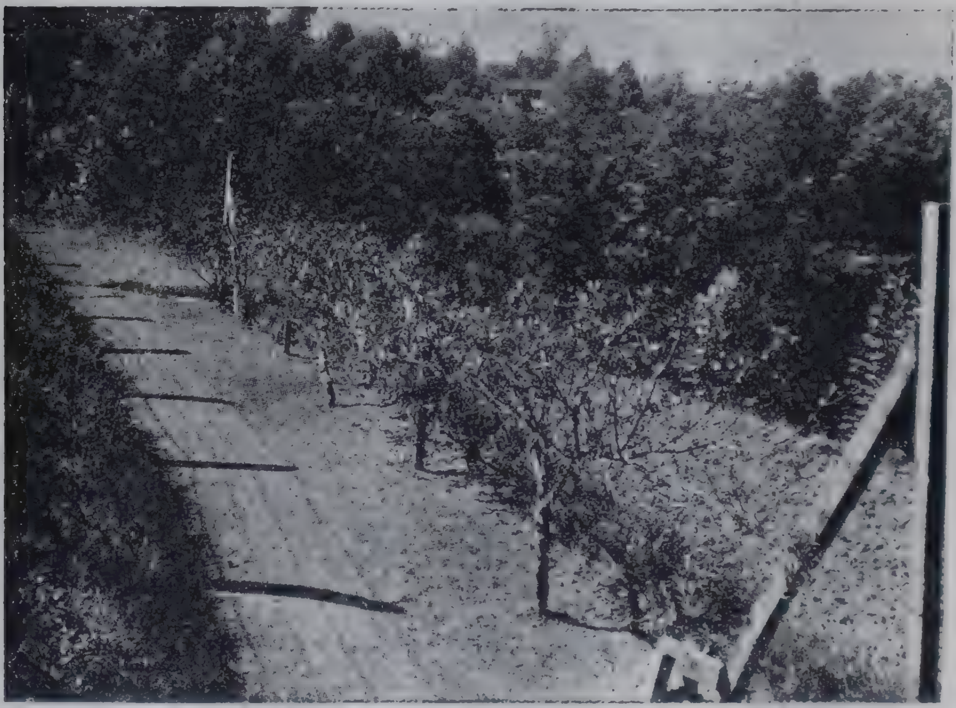

Fig. 91. Cordon training with peaches.

Shanghai Seedling trees are pruned at Coonoor in January, while the Killikrankie is pruned in October before it throws out blooms. The pruning is usually followed up by a spray with one pound of quick lime freshly slaked in ten gallons of water against lichens, or with one per cent. Bordeaux mixture against leaf rust or leaf curl diseases. The latter spray has to be done again in the following April.

Cropping :—Peaches come to bearing in two or three years of planting. The Shanghai Seedling normally flowers in March at Coonoor, while the Killikrankie comes earlier to blossom in November-December. The Killikrankie fruits are ready for harvest in May, while those of Shanghai Seedling are in season in July. The maximum tree yield in these two varieties at Coonoor have been 20 lbs. and 22 lbs. respectively.

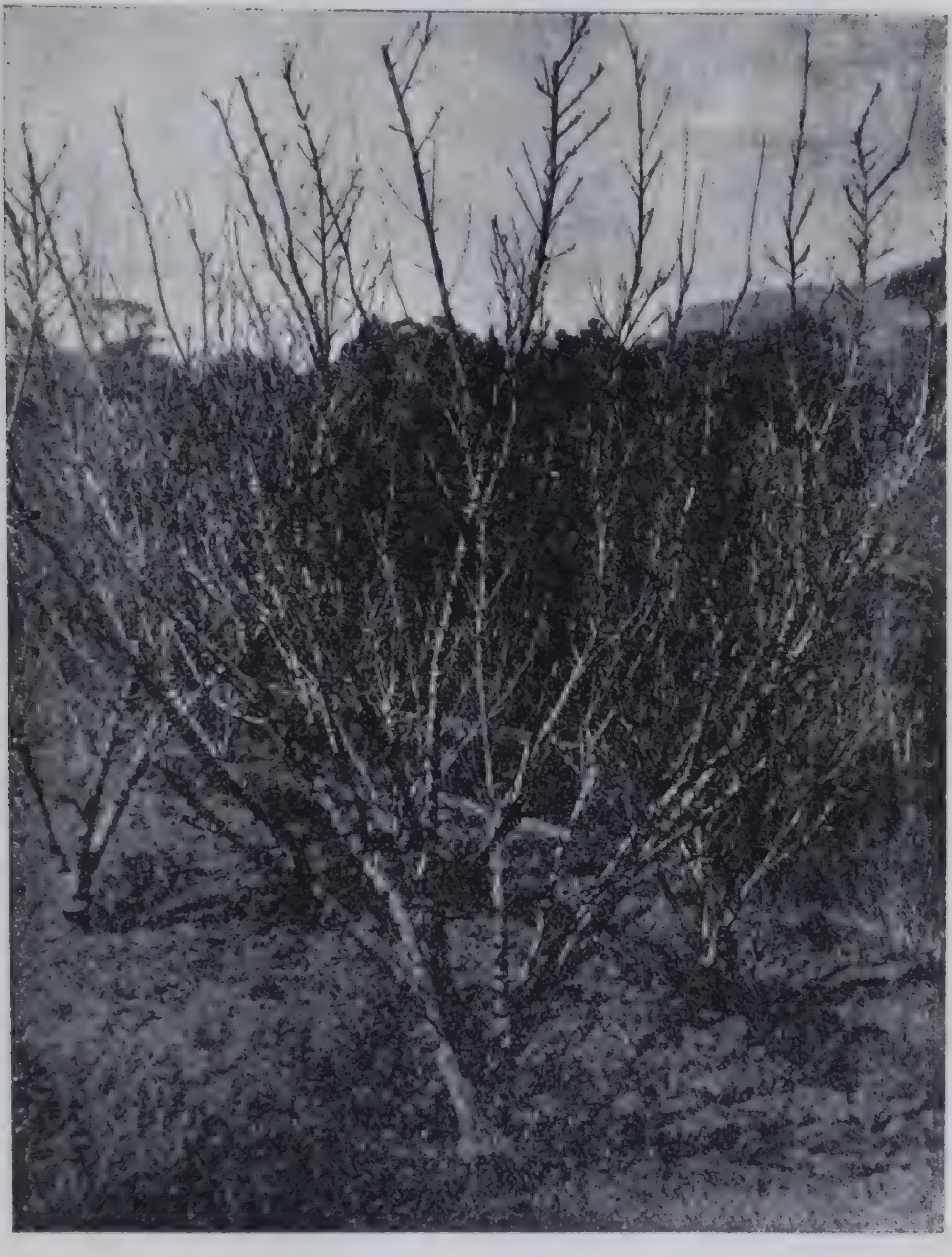

Fig. 92. Peach trained to modified leader.

The peach is relatively a short-lived tree and is not likely to prove remunerative after about 20 years of age. Three trees of Killikrankie and one of common peach planted and trained into cordons at Coonoor in 1944 have established well and appear very attractive. Within a year of planting, they fruited, yielding on an average 20 fruits per tree each of the varieties, in the first two years of cropping. A heavy blossom was also produced in the third year, which gave a crop of about 11 lbs. per tree of Killikrankie and 51 lbs. per tree of common peach.

Nectarines are similar to peaches, but producing smooth-skinned fruits, slightly smaller in size but richer in flavour than the peach. Victoria and Goldmine are the two varieties of nectarines tried at Coonoor, but neither of these has given any clear indications of its commercial value.

PESTS AND DISEASES

Apart from the San Jose Scale, *Icerya purchasii* and fruit flies which affect plums and peaches and which have already been referred to, the following diseases are known to occur on the peach on the hills of South India.

1. LEAF CURL—(*Taphrina deformans* syn. *Exoascus deformans*) :—The infested leaves get thickened, turn rosy and get twisted. The tree also gets stunted, and fruit yields and size get reduced. Removal of diseased leaves and spraying with Bordeaux mixture are recommended.

2. RUST (*Puccinia* sp) :—The lower surface of the leaves is dotted with small, round, powdery, yellowish-brown pustules. The same remedies as suggested for leaf curl are efficacious in the control of this disease as well.

5. APRICOTS (*Prunus* (*armeniaca* syn. *Armeniaca valgaris*)

This fruit is of no commercial importance in South India and is rarely found even in home gardens. However, two varieties —Frogmore Early and Red French have been tried at Coonoor, but with little signs of success. Like the plum and peach, the apricot bears fruits on spurs, sprigs and laterals off the second-year-old or sometimes even older wood. The raising and maintenance of trees are similar to those discussed under peach and plum.

6. STRAWBERRY (*Fragaria vesca* and sp)

Strawberry is grown commercially on elevations exceeding about 4,000 feet above the mean sea level in South India, and more particularly between a range of 5,000 to 7,000 feet. It is a much prized fruit among a section of the residents on the hills. Being one of the most highly perishable fruits, it never appears in the markets on the plains. The fleshy edible portion of the fruit consisting of the enlarged floral axis has seedlike bodies on its surface, which are the carpels or true fruits. By its attractive colour and delicate flavour, the strawberry makes a very attractive table fruit, besides lending itself for the preparation of jams of exquisite quality. One of the most expensive of fruits, strawberry is essentially a rich man's delight, its value being hardly known to the people of lower economic groups in most parts of South India.

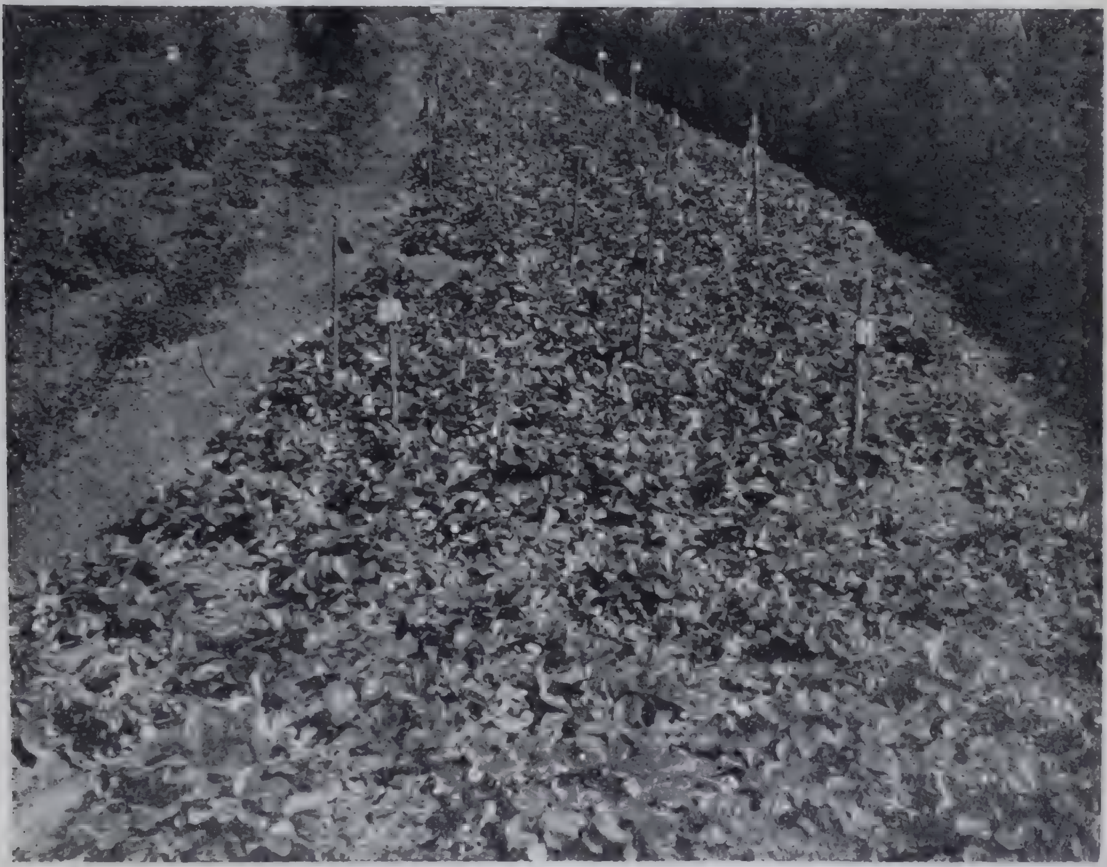

Fig. 93. Strawberry on hill slopes at Coonoor.

Varieties :—A variety of wild strawberry, *Fragaria nilgherrensis* is found on the Nilgiris on elevations of over 6,000 feet. It is a stout, creeping plant and yields fruits which, though edible, are not much relished and therefore possess no sale value.

Of the reported cultivated varieties, Royal Sovereign and Baron Solemacker have been tried at Coonoor, but neither of these have struck the fancy of the growers. During 1940-41, these two varieties failed to produce any fruit at the Pomological Station.

A type which has enjoyed some popularity for over a long time past on the Nilgiris, practically to the exclusion of others, is found to exhibit wide variations in plant characters, so that it is difficult to consider it as a true variety. A preliminary study has revealed this to be a mixture of at least three distinct varieties, plants of the acclimatised Royal Sovereign appearing to predominate. In order to fix a pure clonal strain of high-yielding capacity, work was initiated at Coonoor in 1945. One hundred uniform plants were selected and their performances recorded during one cropping season. This brought out the amazing differences between the yields of individual plants, the yields varying from no fruits in some plants to a maximum of 71 fruits in the best plant, with a mean plant yield of 27 fruits. Splits from each of the 100 selected plants are now retained for further observations and to determine the inheritance of yield characters in clonal progenies, before making the final selection.

Propagation :—The strawberry is propagated by runners or splits from the clumps. During its growing season, the plant throws out in all directions slender stems up to about 15 inches long. If these are in contact with the soil, roots are formed at each alternate node, thus forming a new plant. Such new plants can be lifted out for new plantings. Between the runners and splits a small scale trial at Coonoor has shown that, the latter are superior as planting material. In 1946 while 95 per cent. of the splits established themselves at Coonoor, only 65 per cent. of the runners did so. Apart from this superior stand secured in new planting, the plants from splits also grew more vigorously and flowered earlier commencing in about 75 days as compared to 135 days with runners. The prevalent practice of raising strawberry by runners on the Nilgiris is shown to be less preferable to the planting of splits.

Planting :—The splits or runners from healthy, best-yielding plants are planted out either as an intercrop in tree fruit orchards or as a pure crop. The planting may be done in March or from July to August. The young plants may be set out in single rows in the field or orchard with a spacing of about two feet between the rows and about 10 inches in the row, or in long beds of any convenient size, two or more rows of which are separated by a path, and with a spacing slightly closer than that mentioned above. While planting in the new site, the crown of the young plants should be kept above the ground, and the soil around the roots should be pressed down firmly.

Culture :—Since all the young plants do not succeed in making a successful stand, periodic inspection of the plantation is necessary so as to fill the gaps as soon as noticed. On the Nilgiris, irrigated crops of strawberry have been found to be by far superior to rain-fed crops ; and it is advised therefore to provide for dependable irrigation facilities before the culture of this fruit is attempted.

A shallow rooted crop, the strawberry resents root injury associated with deep soil culture. A mulch with straw or any available leaves or ferns is usually spread under the plants in January or when the flowering commences, partly to conserve moisture in the summer and partly to prevent the fruits from touching the soil. The mulch is removed after the harvest, and may be burnt.

The plant requires to be manured heavily and annually for securing good crop size and weights. About 25 cartloads of well-rooted cattle manure may perhaps be adequate.

The old and decaying leaves of the plants should be stripped off periodically. Such of the plants which put forth a few flowers immediately after planting are also benefited by deblossoming. To secure good crops, it may also be advisable not to retain more than four runners in each stool. The surplus runners may be removed periodically and as soon as noticed.

Cropping :—The plants flower from December to March and the fruits are ready for picking from February to July. The first picking which is light may commence in some areas even in January. Depending upon the season of planting and growth, and care bestowed, it is also possible to secure crops almost all through the year excepting in very cold periods of the year as in December. During wet weather, the strawberry is found to set little or no fruit.

The individual plant yield is very variable, as explained previously ; and a mean yield of 25 fruits per stool is deemed a good average for a season under Coonoor conditions. The crop is removed from the orchard generally after two fruiting seasons.

Being a very perishable fruit, the strawberry requires most careful handling and early consumption. The fruits are picked every day or at least on alternate days during the season, as soon as they are well-coloured, but still firm. The berries must be picked with the calyx attached and with a short portion of the stalk in tact. The fruits are generally sold in small cups or baskets made of light wood or bamboo, to hold one-half to two pounds of fruits in each.

No pests or diseases of any importance are reported on this fruit on the Nilgiris.

Literature

Naik, K.C.—Fruit Personalities—Strawberry—*Mezhichelvam* (In Tamil), Madras. June, 1946.

7. **WALNUT** (*Juglans regia*)

Only a few stray trees of this are found in South Indian hill orchards and these too are not obviously happy. The trees grow slowly and yield crops at irregular intervals.

8. **PASSION FRUIT** (*Passiflora edulis*)

This is a fruit which has been found to thrive very well at Coonoor, yielding heavy crops of fruits suitable as table fruit and for jellies, jams, salads and ices and more particularly for the preparation of an excellent flavoured squash. The vine is also highly ornamental and is worthy of large-scale cultivation along the fence or trained on bowers and pergolas.

Although it is found to grow well at lower elevations up to about 2,000 feet, the vines under such environments are found to run into leaf, failing to produce any crop.

The name passion fruit is said to have been derived from the supposed symbolic representation of its flower parts to the crucification of Jesus Christ. It has been believed that the corolla of the passion fruit flower represents the crown of thorns, the stamens and pistils stand for the nails, and the sepals represent the faithful apostles.

The variety which has given very encouraging performance at Coonoor bears dark purple fruits, which are oval in shape. The shell is hard and incloses yellow aromatic pulp with numerous tiny seeds. As a dessert fruit, the pulp is generally eaten as such or with sugar and cream. It can also be used as spreads.

The vine can be raised by seed or cuttings. Since the seeds germinate slowly, cuttings are generally preferred. These, when taken from well matured wood, strike root readily.

The vines are grown on the trellis, fence or on bowers or pergolas. They may be grown in the form of a pure plantation or as an inter-crop between rows of fruit trees. A spacing of 15 to 18 feet between the rows and 10 feet in the row is deemed adequate. The vines are able to support themselves and require no artificial aid to trail over the stakes and other supporting branches.

The fruit is borne on new wood, and in order to foster such growth pruning of laterals may be helpful at periodic intervals. Occasional thinning of the congested areas and removal of spent wood is also desirable. The passion fruit is exceptionally hardy and requires little attention by way of manuring or watering at Coonoor.

This is in fruit almost throughout the year. Considering, however, the main seasons when bulk of the crop is harvested, the vines bear two crops a year, once in May to June and the other from September to October, commencing from the second year of planting and attaining the maximum yielding stage in about the sixth year. The ripe fruits have a tendency to fall off to the ground, and this necessitates the harvest of well-coloured fruits before dead ripe stage is reached. The picking should be done with a piece of stalk attached to the fruit.

The individual vine yield at Coonoor on bowers has been about 12 lbs. in the second year of planting. The maximum yield may even go over 15 lbs. per vine at the full bearing age.

Because of its hard shell, the passion fruit can stand transport well. When kept for a long time, the fruit shrivels, rendering it less attractive, but without in any way inpairing the flavour or quality.

The fruit is remarkedly free of any pests or diseases under Coonoor conditions.

9. TREE TOMATO (*Cyphomandra betacea*)

A short-statured, highly ornamental tree with oblong fruits, produced in beautiful clusters, the tree tomato is popular on the hills of South India, specially on the Nilgiris both in home gardens and also to a small extent in commercial orchards. Two varieties, viz., one with fruit of yellowish-orange colour, and the other with a dark purplish rind are recognised. The latter is preferred in orchards. The individual fruit is about two inches long, oval with pointed ends, resembling a tomato in rind colour, but being greenish purple when semi-ripe. The pulp is light orange, succulent and agreeable in flavour with black seeds. It is used as a dessert fruit, as well as for stewing. Jams and preserves can also be prepared out of it.

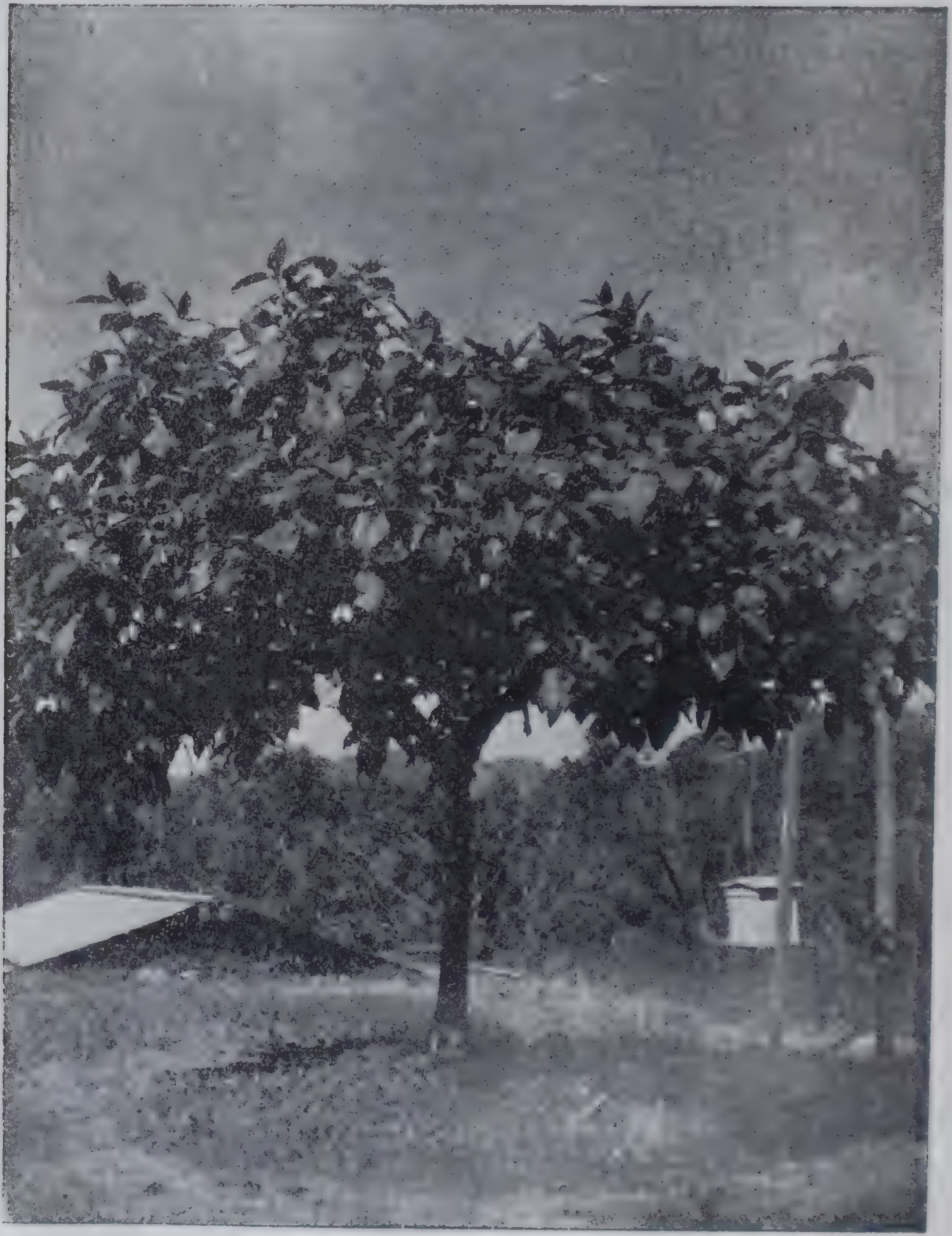

Fig. 94. Tree tomato.

The propagation of tree tomato is by seed, though cuttings are also possible. The seedling is quick growing and commences to yield crops in about two years. Fruits are available for harvest almost all through the year, the peak harvests being from April to September. The mean tree yield is about 40 lbs. per year in a plant of about three years of age. It is believed that this plant has an economic life of about ten years only. At Aruku Valley, tree tomato seedlings planted in June gave the first crop, however, in the following March.

10. PERSIMMON (*Diospyros kaki*)

Though classed as a sub-tropical fruit, the persimmon is found to thrive well at Coonoor alongside the plum, peach and hardy varieties of apple and strawberry. It is also often known by the name of Japanese persimmon, because of its reputation as a staple fruit of high commercial value in Japan. The persimmon has not been tried in all the diverse situations of South India, so that it is only possible to refer at present to its cultural aspects in so far as they relate to Coonoor on the Nilgiris, where alone the fruit has been tried for a sufficiently long period.

VARIETIES

Two wild species of *Diospyros* are reported to exist in South India. One is *D. melanoxylon* or the Coromendel ebony, and the other is *D. tomentosa* which is found in the Circars. Both are said to yield edible fruits. *D. molli. D. virginiana* and *D. lotus* are other introduced species. None of these five species is of commercial value as table fruits, in any way comparable to that of the Japanese persimmon. Only four varieties of the persimmon have so far been tried at the Pomological Station, Coonoor, the brief descriptions of the two promising of which are given under.

1. DAI DAI MARU :—Fruit medium with a broad rounded apex, colour orange red, attractive, surface somewhat glossy with slight bloom ; flesh dark-coloured ; requires curing before it could be eaten : a dependable cropper ; harvests in the later part of September : a moderate grower ; semi-erect in habit : blooms in March.

2. UNNAMED VARIETY :—Fruit large, broad at the base, deep red in colour, attractive, surface glossy ; flesh very sweet when ripe ; requires curing before it could be eaten : a moderate grower with semi-erect habit: a consistent and dependable cropper : blooms in March.

Tanenashi and Hyakume are the two other varieties tried at Coonoor, but which are not considered to have given sufficiently encouraging performance as to merit them to be recommended for commercial plantings.

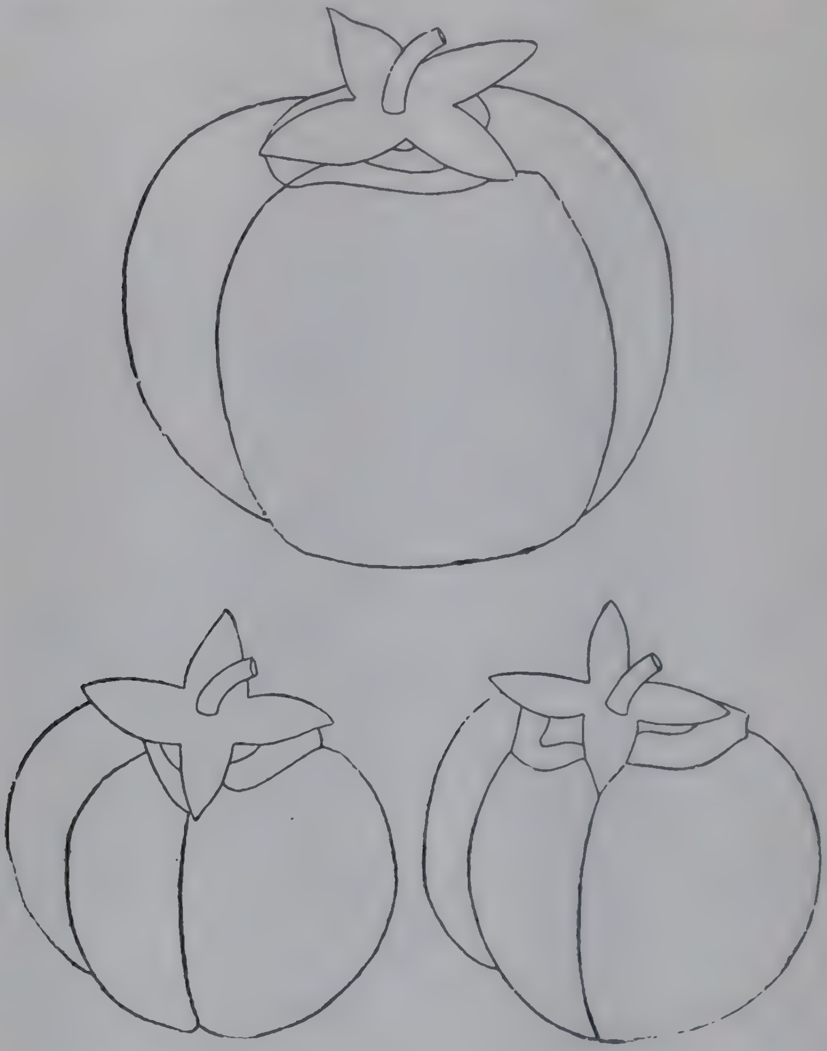

Fig. 95. Persimmon fruits.

Propagation:—The propagation of this fruit is beset with certain difficulties at Coonoor. The varieties in the collection being seedless, seed propagation is ruled out. Attempts made to reproduce the varieties by cuttings and layering have proved fruitless. Vegetative propagation on such well-known rootstocks in common use elsewhere has not so far been possible, since root suckers in the existing plantation rarely appear and seed material of other *Diospyros* species could not be secured. Recently a more successful attempt has been made, but the seedlings are yet too young to enable the record of any useful information on this important aspect. Grafting and budding on *D. lotus*, *D. virginiana*, *D. discolour* and *D. peregrina* are the more well-known methods of propagating persimmon in other lands. The first two species are found to be very slow growing at Coonoor.

Planting:—The trees may be planted from July to January with a spacing of 15 to 20 feet. Like the peach and tree tomato, persimmon can be planted as fillers in longer-lived or taller forms of tree fruit plantations, though they are best grown in solid blocks.

The persimmon trees are either monoecious or dioecious, and bear perfect or pistillate flowers; and one or more of these types of flowers may be borne on any one tree. Tanenashi for instance, produces only pistillate flowers and seedless fruits. The flowering peculiarities of all varieties remain, however, yet to be studied in greater detail. At any rate, in planting the persimmon, it is reported as essential that a variety producing abundant staminate flowers should be interplanted at the rate of at least one tree for every eight trees of pistillate type. It is also stated that the occurrence of staminate or pollen-producing blossoms on a tree is sporadic, i.e., they may occur in one season and not again for several seasons. This fact renders it all the more necessary to interplant varieties as stated above. Fortunately, several varieties, including Tanenashi are also reported to develop fruits without pollination in some countries, but despite this fact the interplanting with pollen-producing varieties is deemed a safe procedure. Dai Dai Maru bears both seeded and seedless fruit, although the former is a rare feature and possibly only when a compatible pollinating variety is in the vicinity.

Pruning:—There is some divergence of opinion on the pruning of this fruit. Some recommend that pruning is unnecessary in bearing trees, except to remove dead, interfering or diseased branches. In China it is reported that thinning of branches is done by cutting back heavily the current year's bearing wood, so as to increase yields in the succeeding year. With trees tending to develop willowy shape, some heading back occasionally has also been suggested. Observations at Coonoor seem to show that some pruning is desirable to stimulate new growth and yield. A pruning trial conducted over a five-year period with Dai Dai Maru has shown that the yields of the trees, whose past season's growth was tipped lightly and also of those whose leader shoots were headed back and laterals tipped, recorded increases over those of unpruned trees, amounting to as much as 17 per cent. in the former case and 22 per cent. in the second. Likewise, there has been an appreciable increase in new growth due to pruning, amounting to 13 and 21 per cent. respectively in the two methods referred to above. The pruning is done in December.

Culture:—Tolerably hardy, the persimmon does not seem to require any special grove cultural practices; those described under the other hill fruits like the apple and plum, being considered adequate.

Croppings:—Persimmons flower in February at Coonoor, and the fruits ripen in about the following September. The first bearing occurs in about five years of planting the trees. The fruits should be clipped from the tree, leaving the calyx and a very short stalk in tact. For distant transport they may be wrapped each in paper and packed in baskets or boxes in single or double layers. The yield at Coonoor has been the highest on an unnamed variety, a single tree having yielded as much as 50 lbs. of fruit in 1946, which in money value works out to Rs. 12-8-0. Dai Dai Maru also is almost an equally heavy yielder.

Curing:—All the four varieties in the Coonoor collection, bear astringent (puckery) fruits until they become fully ripe, for which several processing or curing methods have been suggested. To market the fruits picked direct from the trees will be a futile procedure, nor will the popularisation of this fruit among the growers serve any purpose if they and the public are not educated to cure the fruit, after which alone they are really delicious to taste. After a series of trials, an easy and very convenient method of curing was evolved by Rao at Coonoor. His method, which is now regularly practised at that place is as follows. The fruits when fully mature but hard to the feel are picked from the trees, wrapped singly in paper and kept in alternate rows along with mature Kieffer pears in a closed chamber. The ripening of persimmons occurs in three days when the fruits are completely free from the "pucker", besides being unblemished and very attractive. Other fruits like bananas and tomatoes can also be used in place of Kieffer pears for curing persimmons.

Pests :—No pests or diseases of any importance have been observed at Coonoor.

Product:—Dried persimmons are popular in some countries but have not yet attracted any notice in South India.

List of Reference.

Rao, Narasinga, U.—Curing of Persimmons. The Indian Journal of Horticulture, Vol. 3, No. 1, 1945.

11. MULBERRY (*Morus sp*)

Though generally classed as a temperate zone fruit, the mulberry is found to grow well on a wide range of climatic conditions in South India. The commercial importance of the mulberry in South India, however, is not for the production of fruit, but primarily for rearing silk worms. The fruits though edible and are excellent both for the table and for preparation of jam, are rarely found in the markets, possibly because of their highly perishable nature and partly because of their use for seed purposes.

The area planted to mulberry in South India is enormous; about 70,000 acres are said to be under this crop in Mysore State, about 20,000 acres in Kollegal taluk, and 500 acres in the rest of Madras presidency mainly in Hosur and parts of Palmaner taluk of Chittoor district as well as in Coonoor. Stray trees have also been planted in the arid plains of South India.

The number of varieties in mulberry runs into hundreds, and these come under any one of the three species viz., *Morus indica, M. alba* and *M. nigra.* The varieties differ in such fruit characters as shape, size and colour as well as in edible properties. Those grown for silk worm rearing in Kollegal are mainly types which bear purplish fruits, while the tree mulberry grown for fruits is greenish-yellow fruited. The propagation of mulberry is done by seed and cuttings, largely by the latter. Budding by flute and shield methods are easy, and so are the several methods of grafting.

The mulberry rooted cuttings are generally planted in June-July with a close spacing to give about 4,000 plants for an acre. They are heavily and regularly pruned every year, commencing from the second year of planting for producing leaves to provide forage for silk worms. Trees of mulberry are grown only when edible fruits are wanted. Regular manuring is done for stimulating leaf production in bushes, but trees are rarely manured.

The mulberry flowers in about September-October, and fruits mature from October to November at Kodur; while at Kollegal and Coonoor the fruits mature in February-April. An average yield of one-half pound of fruits per bush can be got when the plantation is raised in silk farms. On the trees, the individual tree yield is about 7 to 15 lbs. per annum on the plains. The leaf yield per acre in bushes is about 3,000 lbs. per acre per year, obtained in six to seven pickings.

12. CAPE GOOSEBERRY (*Physalis peruviana*)

A small shrub, the Cape gooseberry is found to grow both on the hills and the plains of South India; in the former case up to an elevation of about 6,000 feet from the mean sea level. The fruit of this plant is a berry which is pleasantly acidic, containing numerous tiny seeds and of sufficiently good flavour to be relished as a table fruit as well as for jam making. The berry is enclosed in a prominent dry and papery calyx. Except at Coonoor, it is rarely cultivated on a commercial scale, and even there to a small extent. The adaptability of the plant and its hardiness are such as to permit its culture even under relatively infertile soil conditions. These are perhaps responsible for the neglect shown towards this fruit.

The variety grown at Coonoor is believed to have been introduced from South Africa several years ago. It produces large crops of good-sized fruits, unlike the local varieties found on the plains, as well as on the Shevroys almost in a semi-wild state.

The propagation is by seed. The seedlings are transplanted in rainy season, when about 6 to 8" high, into permanent sites either as inter-crops in tree orchards or as pure plantations. They may be grown in flat beds or on the sides of ridges. Preliminary trials at Coonoor show that layering and rooting of cuttings are feasible.

In almost all parts of South India, the Cape gooseberry is raised or found entirely as a rain-fed crop, excepting for one irrigation given immediately after planting.

The seedlings commence to flower in the first year of planting itself, generally in about November, in case the seed was sown about 10 to 12 months earlier. At Aruku Valley, however, it was observed that seeds sown in July produced plants fit for transplanting in two months. These flowered in the following October, with fruits ready for harvest by March next. Only bush-ripe fruits are gathered. The peak harvest season is from January to May in Coonoor.

There is tremendous variation in yields of individual plants. During 1946 a study of plant performances in 97 selected bushes showed that the range was so wide as to extend from less than a score of fruits to 227 fruits per plant. Selection of high-yielding plants and establishment of clonal strains may offer a means of exploiting this feature of high variation in yields. An acreage yield of over 30,000 lbs. of fruit has been secured in Aruku Valley.

The Cape gooseberry bushes are considered uneconomical to maintain after about four years.

List of Reference

Naik, K.C.—Fruit Personalities, Cape Gooseberry—*Mezhichelvam* (In Tamil), Madras, September, 1945.

13. **SURINAM CHERRY** (*Eugenia uniflora*)

This is also referred to in foreign literature as Pitanga or Brazil cherry. It is a small scraggy bush, producing beautifully crimsoned or scarlet-coloured fruit, resembling the true cherry in appearance. When fully ripe the fruit is aromatic and highly decorative, and can be used for eating out of hand, even though it is slightly acidic. For jelly and sherbet also the fruit lends itself well. It thrives on the higher elevations as those at Coonoor as well as on the lower slopes up to an elevation of about 1,500 feet on the Nilgiris. Being a very hardy plant, little attention is required to raise and tend the bush. It is propagated by seed. It can stand clipping and therefore is suitable for raising live-hedges. The plant fruits in the fourth year of planting and the crop is gathered in March-April. A mean plant yield is estimated at 6 to 8 lbs. per year.

14. **FEIJOA** (*Feijoa sellowiana*)

This is another hardy and very ornamental fruit plant growing into a small bush and adapted to the same conditions as those of Surinam cherry. The fruit is oval or oblong, dull green in colour, possessing a whitish bloom, and often blushed dull red on one side. The flesh is granular, jelly-like, sub-acid and whitish, containing several tiny seeds. The fruit is also aromatic and can be eaten when fully ripe, besides being suitable for jam and jelly. The propagation is by seed, and the seedlings begin to crop in the third or fourth year. The fruit matures from September to December. Red and yellow fruited varieties are said to exist, some of which are reported to be self-sterile, but it is only the variety producing red colour when ripe with bronze markings on the rind, that is popularly grown on the hills in South India.

15. **CHERIMOYER** (*Annona cherimolia*)

Considered by many as the choicest of the *annonas* from the view-point of fruit quality, the cherimoyer is also the only *annona* which can be grown successfully on the higher elevations. It has been found to thrive on elevations up to about 7,000 feet in South India as well as up to a lower limit of about 1,500 feet above the mean sea level in the warm humid zone. The production of this fruit is at present limited, but it affords scope for extension, in view of the fact that it is one of the few fruits which are in season in December and January on the hills. Though less sweet than its relative, the custard apple, cherimoyer is liked more by many as a table fruit, because of this very characteristic, and also because of its buttery consistency and a peculiarly delicate flavour.

There are no varieties in cherimoyer, so far as is known. The one that is under cultivation in South India produces small to medium-sized fruits, resembling externally the custard apple excepting in having a more abruptly rounded apex and smoother skin and in assuming a dark colour when ripe.

The cherimoyer is generally propagated by seed, but it has been found at Burliar and Kallar Fruit Stations that it can easily be inarched on the bull's heart and possibly on other *annona* species as well. On the former, the successful "take" has been over 90 per cent. The cherimoyer grafts on bull's heart have also been found to crop better at Burliar than the seedling trees of cherimoyer, commencing to bear also earlier i.e., in about the sixth year, as against the non-bearing state of the seedlings even till the eleventh year.

The planting and culture of the cherimoyer do not call for any special mention, and are not dissimilar to those of other hill fruits.

Left to itself the cherimoyer develops an unattractive scraggy growth with congested parts and wide gaps occurring irregularly. The optimum training and pruning practices have not yet been worked out, but it would appear that a better tree shape can be secured by timely removal of misplaced limbs and by cutting back new growths to an inner or outer bud according to the direction in which new growth is required to be regulated.

The crop yield of cherimoyer is considered low, being generally not more than 100 fruits per tree per year. It has been suggested that hand-pollination might help a better fruit set. The fruits mature in December. As soon as gathered, the fruits should be kept in a well-ventilated room, where they will ripen in about a fortnight.

16. STRAWBERRY GUAVA (*Psidium cattleianum*)

This is an ornamental shrub, fruits of which are tiny, but resembling the common guava. The plant is found at home on the hills between about 2,500 to 5,500 feet elevation, but it has also been found possible to grow it on the plains. As a table fruit, it is of little value, but a good jelly can be made out of it. The propagation is by seed. Being hardy it thrives even under neglect. Cattley or Chinese guava are the names sometimes applied to this fruit. Its fruits are in season from July to August and again from January to February on the plains.

List of References—General.

1. Naik, K. C.—Government Fruit Stations—What they stand for? Villagers' Calendar & Guide, Madras, 1944.

2. „ Short Notes on Hill Fruits, Villagers' Calendar & Guide, Madras, 1943.

17. OTHER BUSH FRUITS.

Small scale introductions of raspberry (*Rubus sp.*) and blackberry (*Rubus sp.*) have also been made at Coonoor and Bangalore. Both are being propagated by rootsuckers and the former also by tip layering. At Coonoor the former fruits in about three years from planting, while the latter reaches the bearing stage a year earlier. Both mature their crops in May-June. Raspberry has not yielded any large crops yet, but the blackberry plants have borne as many as 352 berries on each, of which roughly 90 fruits go to a pound. In regard to training and pruning both these fruits appear to demand identical methods. Once planted they both produce a number of canes, which may be trained on stakes or trellis. The canes produced in one year, produce fruits in the next, after which they are cut down. The process is repeated with the new canes emerging every year. As table fruits both these fruits are not yet popular, but for jam they may enjoy popularity.

CHAPTER V

GRAPE, FIG, POMEGRANATE AND LOQUAT.

Introduction:—Although the first three fruits are now found in all the varied climatic zones of South India, they have so far attained the greatest commercial importance on the plains. Entirely unrelated to each other, they are nevertheless brought under one chapter because of their adaptability, generally speaking, to the largest sets of conditions prevailing in the region.

1. GRAPE (*Vitis vinifera*)

Grape is generally considered to be a commercial fruit of the temperate zone, but experience in viticulture in South India has proved that the yields and quality of grapes produced in certain situations under the tropical conditions of South India are in no way less than those reported from what are usually considered as the ideal home for the fruit. Commercial viticulture is at present confined to a small area near the foot of the Kodaikanal hills in Madura, specially in and around the village of Michaelpatti and Pattiveerampatti, as well as in Krishnagiri and Penukonda in Madras Presidency and Bangalore in Mysore State. Stray instances of success have also been reported from many other parts of South India, including Tinnevelly and Coimbatore districts and even the sandy coastal area of a heavy rainfall tract as the West Coast, as well as from the higher elevations on the hills such as around Ootacamund and Kodaikanal. While these serve to emphasise the amazing adaptability of the grape, it cannot be denied that the viticultural enterprises in and around Pattiveerampatti village of Madura District are of a unique nature, in that they have established clearly that, under intelligent and assiduous care and on suitable soils the grape can be one of the most remunerative fruits of South Indian plains, producing heavy crops of excellent quality in two clearly marked seasons of the year—a feature unknown in the viticultural areas of the temperate zone. The main harvest seasons in South India are March to May and August to November in Madras presidency, and June to September and December to March in Mysore State, while the seasons for Baluchistan grapes extend only from June to November. The March to May crop from Madras enters the markets, therefore, at a time when North Indian supplies are absent. This is a distinct advantage which should serve to stimulate the viticultural industry in this part of the country.

Production:—According to the Agricultural Marketing Adviser to the Government of India, about 250 acres are planted to the grape in Madras presidency, of which roughly 150 acres are in Madura, 80 acres in Salem and 20 acres in Anantapur districts. Mysore State has about 50 acres devoted to this fruit, mainly in and around Bangalore. The total acreage in South India works out therefore to only a little over seven per cent of that in the country (Undivided India), or over 12 per cent. of that in Baluchistan, which claims 58.2 per cent. of the viticultural area in the country. Considering the annual production, however, the South of India claims about 6.5 per cent. of the total crop produced in a year, with Madras claiming about 4.8 per cent. (18,000 maunds), and Mysore about 1.7 per cent. (6,333 maunds), while Baluchistan has about 49.7 per cent. of the annual production to its credit. The foregoing statistics published in 1940 are believed to apply no longer, in view of the appreciable rise in acreage and production in Madura district in the recent past.

Climate and soil:—The secret for the wide range of adaptability of the grape seems to lie in the existence of numerous varieties, each with its own peculiarities and degree of adaptation, and also in the success of the devices made by the growers to adjust the variety to a given environment by suitable viticultural practices. For instance, it is well-known that heavy rains during the grape flowering and harvest seasons is a serious limiting factor. The grapes should therefore be made to reach the flowering and the peak harvest seasons before the seasonal rains commence and cause havoc. Otherwise, the fruit set may be inhibited or the berries may be spoilt in eating and keeping qualities. In most parts of South India the flowering and the harvest seasons for the first crop synchronise with the driest part of the year, so that no risk is involved. In the case of second crop, however, the north east monsoon showers usually occur in heavy torrents in September in Krishnagiri, while in Madura district such showers are experienced normally a month later. To that extent there is a greater safety for the second crop in the latter district. In Mysore State, August to September are the heaviest rainy months and the growers therefore find it to their advantage to have the second crop in season in a drier period such as from December

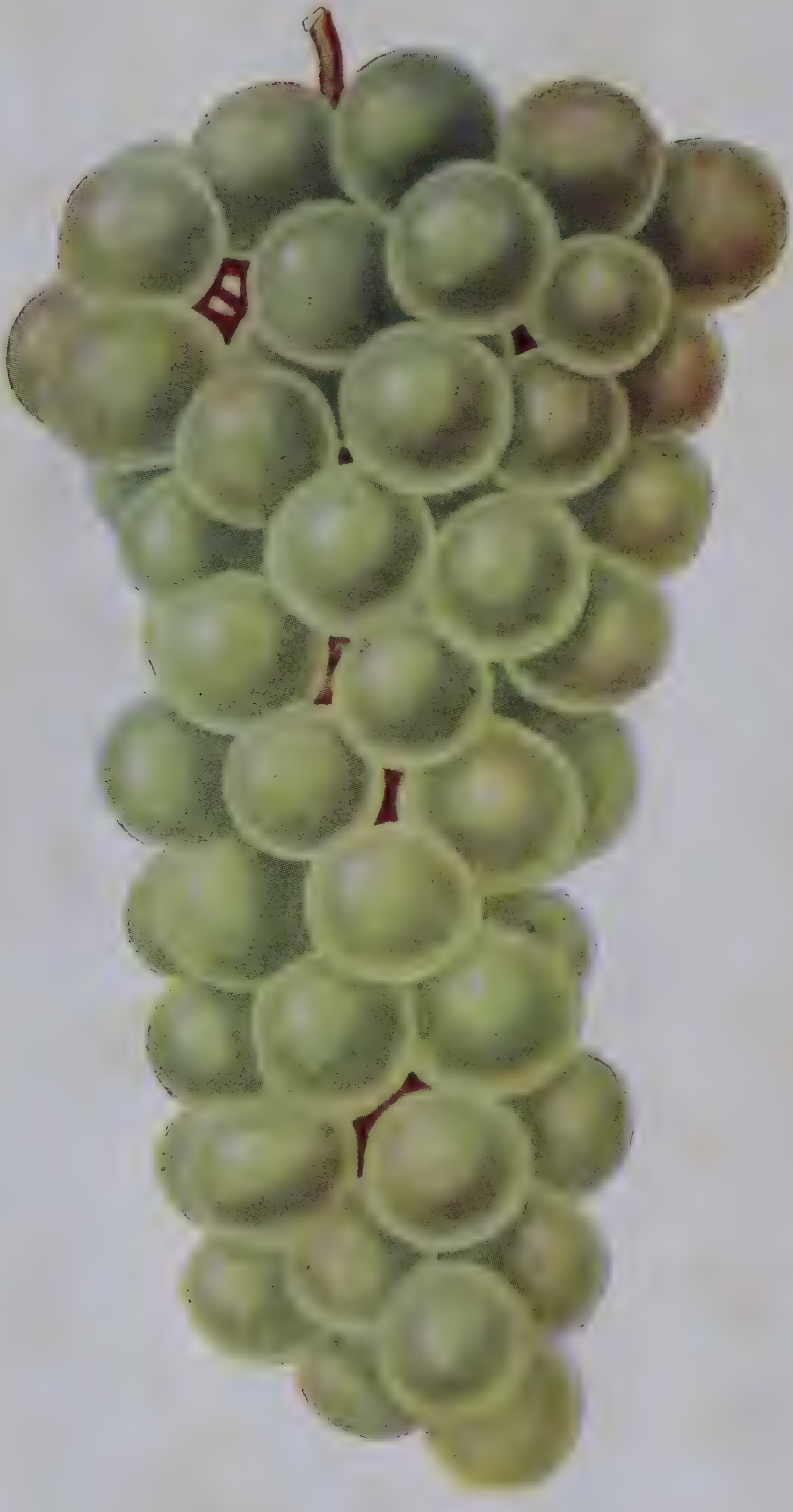

PLATE VII. PACHADRAKSHA BUNCH

(To face page 369)

to March, even though this season is sometimes too cold for the vine to grow and mature crops. This necessitates pruning for the first crop only in April, the crop of which also comes to maturity in a relatively dry period as from June to the beginning of September. Heavy rains produce a damp atmosphere, both of which favour the development of mildew, which in turn causes marked decline in yields. High winds which usually prevail in July-August in South India also cause some damage occasionally; and in order to minimise or avoid such damage, sheltered positions and thick wind-break belts are found useful.

A deep, well-drained loam is considered the best medium for the crop in South India. The soil devoted to some of the best vineyards in Madura district is gravelly and open-textured, deep and red in colour. Such a soil under heavy manuring and under the peculiar training and pruning methods and periods as adopted in Madura district, has been found to enable the grape growers to secure even larger crops on some varieties than those reported from Baluchistan. Near Penukonda, clayey soils have been used for raising vineyards by some persons, while red or ash-coloured alluvial soils have also been preferred elsewhere for the crop. In all soils of close texture, a good admixture of gravel or sand is considered essential for promoting free drainage.

VARIETIES

1. *Green* (*Pachai-drakshai*) :—This produces green berries which attain a light yellowish tint when fully mature. The bunch is compact and medium in size, cylindrical and tapering to the lower end. The berry is large, roundish, with soft and juicy pulp. Taste is sweet when fully ripe, but piquant. It is seeded, a fairly good keeper and heavy yielder. It is grown largely in Madura and Salem districts.

2. *Blue*:—This also goes by the name of Aurangabad or Bangalore Blue, and is grown largely in Anantapur district and Mysore State. It produces dark purple berries. The bunch is medium-sized, very compact and slightly shouldered. Berries are round or ovoid; skin thick, tough and astringent and easily separates out in the mouth. The pulp is mucilaginous, aromatic, and very sweet when fully ripe, though sub-acid. It is seeded, and has a lower keeping quality than the green grape. It is also very prolific.

3. *Kishmish*:—The seedless grape introduced some years ago from Baluchistan to Pattiveerampatti in Madura district and since which time has been making a rapid headway in that district is called either Kishmish or Bedana. From the general appearance of the bunches, it appears that the vineyards in Madura at present contain under the above name, two distinct varieties viz., the Sultana and Bedana. The former is synonymous with the Speen Kishmish or the White Kishmish of Baluchistan, while the latter seems to be the true Bedana of the North-West Frontier Province. Brief descriptions of both are given below.

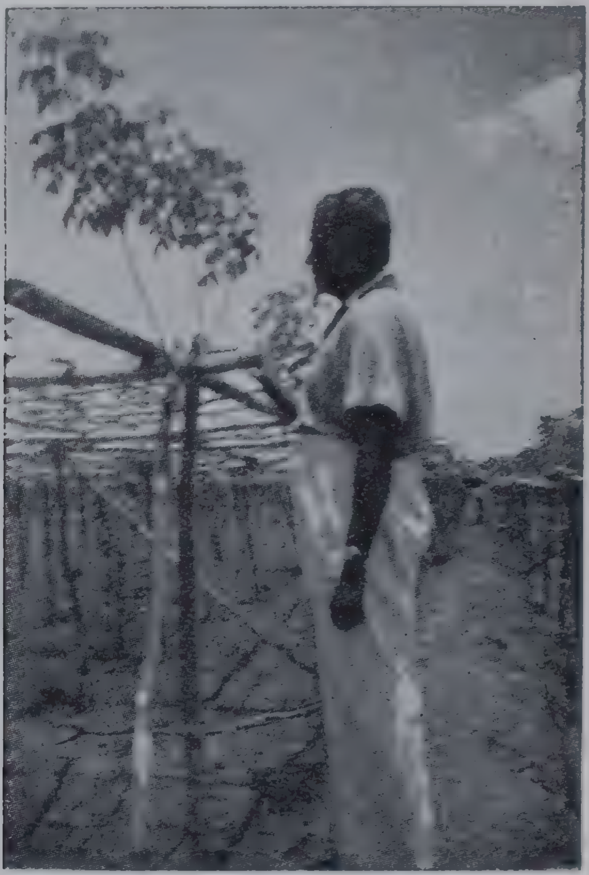

Fig. 96. A Kishmish vineyard at Pattiveerampatti.

(1) *Speen Kishmish or Sultana*:—Bunches medium, shouldered and with many branches, fairly compact; berries small, round and often tending to be oval, and translucent; skin very thin and whitish when ripe; pulp firm, sweet and of good quality; seedless usually, but a few seeds may be found occasionally.

(2) *Bedana*:—Bunch medium, shouldered, very compact and almost conical; berries small though slightly larger than (1), and oval; skin thin and greenish yellow when ripe; pulp very sweet.

soft and of very good quality; berries are likely to shed from the bunch in storage. Seedless.

Many other varieties have also been introduced and tried in South India, including some from Australia and the United States of America; and some 25 varieties exist in the vineyards of the Government Fruit Research Station at Kodur. The commercial importance of none of these is such as to deserve mention at the present stage. The famous seeded white grape of Baluchistan, the Haitha, has also been tried and possibly may offer a chance of spreading into home vineyards in Madura District, but its commercial possibilities are insignificant as compared with the Speen Kishmish and Bedana.

Propagation:—For commercial cultivation, grape is universally propagated by cutting. Mature wood of the previous season's growth is selected from the prunings in a dormant season; and from this, cuttings having medium spaced internodes and of the thickness of an ordinary pencil and each eight to ten inches long, are prepared. The cuttings so made are planted in pots or preferably in flat nursery beds, immediately after they are prepared. Some growers in Madura district also plant the cuttings direct in the vineyard site. Layering is not of any commercial value, though it is possible. Seed propagation is resorted to only in breeding work and is of no interest to the grape growers, since it is not only a slow process but cannot also be depended on to produce vines true to parents. Although grafting and budding on resistant rootstocks have proved to be valuable in the United States of America, saving the viticultural industry of that country from the ravages of the phylloxera pest, the need for employing such methods of propagation has not fortunately arisen in India, owing to the fact that the pest has so far not been reported from any part of the country. Phylloxera is a plant louse which attacks the roots of susceptible vines and kills the plants. The only effective remedy known is to graft the susceptible variety on an immune rootstock. That grape can be easily grafted under South Indian conditions has however been established from a trial at Kodur, where a few vines have been successfully yema-grafted using several varieties of cultivated grapes as rootstocks.

The grape cuttings strike root easily under ordinary care and the rooted cuttings become ready for planting out in their final sites in 6 to 12 months. The rate of growth however depends greatly on the environment, the most rapid extensions of growths having been observed in Madura district. It is also possible to raise large sized vines quickly by layering, by selecting vigorous one-year-old or older canes. Where vines are planted close to each other, layering may also be helpful in filling up the gaps in the vineyards. In such cases, a full grown cane is selected and is bent down in the middle or at an appropriate place. The bent portion of the cane is then buried inside the soil, after giving a cut to the cane at the part to be buried or after slicing off a small part of the stem at the same part. The treated portion after being buried in the soil has to be watered frequently as in the case of cuttings. Three to six months after layering, the layered cane is separated from the mother vine, to form a separate vine.

Planting:—Although grapes can be planted throughout the year in South India, they are usually planted from June to January. January planting is most popular since it is believed that vines planted in that month make quicker and more vigorous growth than others.

Fig. 97. Holes dug for grapevine planting.

It is also a widespread belief among the grape growers in Madura side that, much care in preparing the pit is necessary to provide optimum growth and performance in the vine. About six months before planting, large pits or trenches are therefore dug out at the required spacing and these are filled up after a short period of weathering first with green leaves to a height of about two feet and covered over with or without anyone or more of the following: bone meal, tank silt, well-rotten sheep or cattle manure, loose red or ant hill earth or leaf mould. The above mixture may be repeated in successive layers to fill the pit or to refill it when the contents settle down as a result of decomposition, aided by repeated watering of the pits and occasional turning over of the mass. A small hole sufficient to accommodate the root system is made at the time of planting and the rooted vine is placed inside. Many prefer to plant unrooted cuttings at the rate of one or more to a pit. The soil is firmly pressed around the cutting or stem of the vine, after which a copious watering follows. A small bamboo or wooden stake is then planted in each pit to serve as support to the growing vine if the live stakes are not established by then. A mixture of *margosa* cake powder mixed with sand is sometimes sprinkled around the cuttings soon after planting and this is claimed to prevent the white ant attack.

The spacing of the vines varies largely, depending mainly upon the system of training adopted. In Krishnagiri, where the training of the vines on arbours supported by stone pillars is popular, the spacing is the widest, leading only to about 40 vines for an acre. Near Penukonda also, pandal or arbour system is in vogue, but having mainly jungle wood supports or pillars. The more popular spacing at Penukonda is between 25 to 30 feet. In Madura district the spacing for vines is much closer, leading to about 200 vines to an acre, even though the pandal system is followed, supported by either wooden or live-posts of such quick-growing plants as *Erythrina indica* or *Kiluvi* (*Commiphora beryii*). In some vineyards in Madura as well as in other Tamil districts, a spacing of 36 feet between rows and eight feet in the row when planted in trenches, or eight feet both ways when planted in pits, is also common. Arbours supported by stone pillars are also the rule in Mysore State, although here the spacing varies much according to the fancies of the individual growers and to a certain extent depending upon the varieties grown—that for Blue variety being generally 15 to 20 feet. For vines trained by the cordon system, a spacing of 10 feet has been found adequate at Kodur.

TRAINING AND PRUNING

The training and pruning methods as applied to the grape have received a great deal of attention from research workers in many lands and consequently many systems have been evolved to suit the given sets of conditions. The varieties of grapes differ so markedly in growth and fruiting habits and the climatic conditions between the viticultural regions vary so widely, that no one system of training or pruning has been found suitable for all the grape vines. Most of the systems evolved, relating as they do to different climatic conditions, do not lend themselves for adoption in South India. The absence of a severe cold season on the plains of this region and the consequent ability of the vines to enjoy a relatively longer growing period, as well as the capacity to produce two crops in a year, provide therefore a set of features, which necessitate a different approach in South India. Thus, while the pruning is done only once a year in almost all parts of the world including Baluchistan and North-West Frontier Province, two prunings per year are done in South and Western India. It is also found that the growth of the vines in the first year in Madura district is markedly more rapid than in the other parts of India. Actual trials to determine the best training and pruning practices for the South Indian commercial varieties of the grape

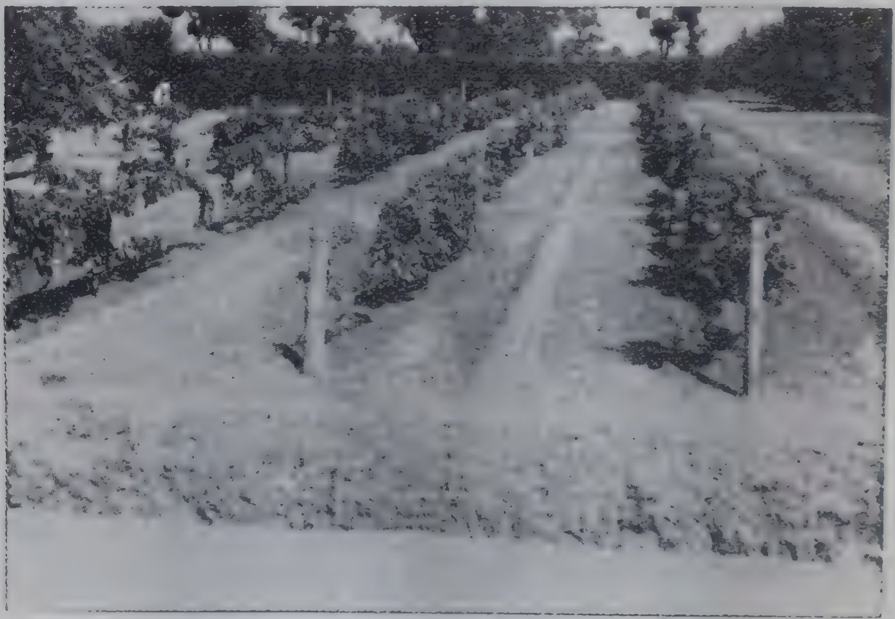

Fig. 98. Grapes trained on wire by cordon system.

are yet to be done. So far, only the experiences of the growers and that of the workers at Kodur on the pruning of vines trained to a cordon system are available. The following methods relate therefore to only these few methods followed in this part of India.

At the time of planting or soon after it, the vine is pruned off its side shoots to leave only the leader shoot to form the trunk, although some growers prefer to leave two trunks per vine occasionally. As the vine grows on a support, all secondary growths or side shoots are suppressed, so as to divert the energy of the plant for the building up of the main trunk or trunks. The vine is thus allowed to attain a height of five to six feet, after which it is allowed to ramble over the arbour or pandal specially erected for the purpose with cheap wood as of *Sesbania sp.* or sometimes even of superior wood. It is believed that the provision of roof for the pandal alone costs sometimes Rs. 1,000 or over per acre. The pandals are not of any standard dimensions nor of any fixed shape. The latter is often ingeniously altered to conform to the shape of the terrain or to that of any permanent structure in the vineyard. The live supports of *Erythrina indica* or *Commphora beryii* are commonly used in Madura district as supports to the vines and pandals, the latter enjoying greater popularity in recent plantings. The cuttings of these strike root readily even when taken from large limbs, which are planted along with the digging of pits. Both the top and root portions of these two species stand hard pruning. As a matter of fact they are cut back twice a year, and the leaves of the *Commiphora* are also used as green manure. Live supports are not attracted by white ants, and possess the advantage of providing some shade to the vine during the hot weather. Supports of jungle wood and stone or those built from brick and mortar or even iron pillars are also used in some parts of South India.

As the vines grow, side shoots are frequently removed. When the vine reaches the top of the pandal, the growing point is nipped off. The side shoots are trailed off in the desired direction so as to regulate the spread and to prevent congestion. Tendrils are removed periodically so that the shoot may not be fixed down to any position other than that selected for it. Loose tying of the shoots to the pandal with fibre is done carefully.

As soon as the vines attain the bearing age and spread over the pandal, bower or arbour, regular pruning commences for the crop. Neither the method of pruning nor even the time of pruning for either of the two crops in a year is standardised. Commonly, however, for the summer crop the pruning is done in the preceding December-January, while for the second crop the pruning is done in May-June. In Mysore State where the crops commence to ripen in June and December, the prunings are done usually in March-April and September-October respectively. The usual practice in both the seasons is to cut back all past growth on the pandals or bowers to three to seven buds. Most of the enlightened growers at Madura, however, cut back to four to five buds in December-January and to only three buds in May-June. No attempt is made to regulate the crop according to the health or capacity of the vine, by restricting the fruiting wood at the time of pruning. In the case of vines trained on a pandal, bower or arbour, the ideal is to have a strong vine with a well-formed straight trunk with two to four fruit bearing canes or arms. The fruiting wood left on each vine and on each arm or cane should be correlated to the vigour and age of the vine, so as to ensure its progressive development and health. Leaving excess of fruiting wood will exhaust the vine and lead to poor growth, and consequently there will be a decline in yield in the succeeding year. Even so, retention of a low amount of fruiting wood will result in excess of growth at the expense of fruit production. For good fruit production, it is now known that the fruit-bearing wood should arise as close to the trunk as possible, i.e., near the head of the vine where it spreads out over the pandal. If the spacing is very wide in the vineyard the trunk can be allowed to extend in two or more arms to form the fruiting wood, whose number has to be regulated at each pruning.

The number of buds to be left on each cane at the time of pruning is also a very important consideration to be reckoned with at the time of pruning. Usually the basal bud on every cane fails to produce fruits. In some varieties a longer piece of cane up to seven or eight buds has to be left for getting good yields, while in others four to five buds are all that are necessary. Taking the vine as a whole, it is suggested that 40 to 60 buds are all that should be left at the time of each pruning. Since the length of the cane is of no importance, but the number of buds on each fruiting cane is, and assuming that five buds on each cane are sufficient for the commercial South Indian vines, it will be necessary to leave only 8 to 12 fruiting canes on each normal bearing vine during each pruning operation. More buds or fruiting canes may lead to over-bearing, while less may lead to over-vegetative condition. All canes as well as the weaker growths above the number suggested above may be pruned off.

Based on the methods adopted in Bombay Presidency, some growers prefer to adopt a different method of pruning, which goes by the names of "forward" and "back" prunings. According to this, the pruning for the first crop of a year is done by leaving three to five buds at the base of each cane, while for the second crop the canes are cut back to leave only one or two buds. All weak canes are also cut back to one bud or pruned away completely. The former of these is believed to lead to production of good crops, while the latter is said to lead to the production of fruiting wood, from which the fruits are secured by the succeeding pruning operation.

In the cordon or bush trained vines, the trunk is allowed to grow to a height of about two feet, after which the vine is allowed to throw out fruiting wood as in the case of bush system, or arms over a wire or trellis as in the case of cordon. In the latter case, the arms may be one to four, and may trail over a trellis or in one or more tiers. After the vines are trained to any of these systems, the method of pruning is not dissimilar to that described under the pandal system, except that the number of buds to be left per vine is smaller (about 20 to 40) than in pandal trained vines, so as to suit the small size of the vines. Since the vines are spaced close to each other in bush or cordon trained systems, the acre yields are believed to be not less, even though the individual plant yield is very much smaller.

A system of root pruning of grape vines is prevalent in some parts of South India. In such cases water is withheld from the vines for about a fortnight prior to the pruning. A trench, four to five feet deep, is then dug all around the plant and the roots are thus exposed for a few hours, after which the dug-out soil is mixed with cattle or sheep manure and sometimes with oil cakes and red earth, and replaced in the trench. Watering is done on the day following the filling up of the trench, and is continued at regular intervals thereafter. It is not certain if this root pruning operation is at all necessary for successful grape production.

Observations seem to point out the evils associated with the wide-spread practice of pruning the vines indiscriminately in South India. Too early or too late prunings in a season are two of the widely prevalent evils, which serve to devitalize the vines on one hand, and lead to a serious crop diminution on the other. Excessive pruning, whether of the top or root, cannot but also do serious injury to the vines.

Culture:—Grape is an intensively cultivated fruit crop and responds well to careful tending. Timely irrigations and frequent shallow culture to keep off the weeds are deemed necessary, as also heavy annual applications of manures. In Madura district the bearing vineyards receive annually about 50 cart-loads of green leaves and 100 to 200 cart-loads of farm yard manure per acre. Sheep penning is also practised by some growers, while some also apply *Kolingi* leaves. This will be considered normally an excessive dose in other soils and places, but in the open, deep and well-drained grape-growing soils of Madura district, the benefits of such heavy manurial applications are reflected in the remarkably robust growth and high yields. About 70 cart-loads of manure are also applied to the acre in parts of Salem and Anantapur districts, besides an application of fish manure at the rate of six bags per acre a few days after one of the prunings in the year. The Penukonda vineyardists also apply to each vine at the time of pruning four visses of gingelly cake powdered and fermented in butter milk. The exact benefits of this application are yet to be determined. As in all other operations of viticulture, the manurial requirements of the grape have yet to be experimentally determined for the various tracts of South India.

Cropping:—Although the grape commences to yield some crop in the second or third year of planting, a good sized crop can be expected only after the third year. At Tirupur a vineyard planted on 1-1-'47 and pruned on 1-1-'48 to three buds on each cane, and new growth tipped on 1-2-'48 yielded on 10-4-'48 a crop of 0.3 maund of fruits on Seedless and 0.5 maund on Green grape (one md.=25 lbs.). The second crop was got in August and was slightly less. According to one report from a leading vineyardist of Madura district, the first crop in Green grapes in an adult vineyard account for an acre-yield of over 50,000 lbs., while the second crop may amount to about 20,000 lbs. With the seedless Baluchistan varieties, his estimate is 16,000 lbs. for the first crop and 8,000 lbs. for the second crop. The Agricultural Marketing Adviser to the Govt. of India estimates the yield to be 7,000 lbs. in Madura district, 5,000 lbs. in Salem district and 11,610 lbs. in Mysore State, as against the average acre-yield of 7,380 lbs. for the whole country and 7,678 lbs. for California. It is difficult to reconcile these divergent figures, but any one visiting the vineyards at Pattiveerampatti in Madura district is likely to be struck with the prosperous look of the plants and may be led to the inference that viticulture in those parts is by no means inferior to that in any part of the country, and that the yields there are not unlikely to be far above those in the rest of the country.

Unrooted cuttings of the green local grapes planted in January have been found to produce their first crop in March-April of the following year, and according to one report this first harvest gave 7,500 lbs. per acre, followed by a yield of 15,000 lbs. in the following August-September. The yield is said to have more than doubled itself in the succeeding year. In adult vineyards, the first or summer crop is usually heavier and sweeter, but in Kishmish where the annual yield rarely exceeds 16,000 lbs. per acre, the ratio of first and second crop is usually 2:3. Untimely pruning or chance occurrence of rains may upset calculations and reduce or even destroy a crop completely.

Although the season for grape commences in March and August, the peak harvest occurs in April for the first crop and September for the second crop. In Mysore State, the peak periods are July-August and February.

Harvesting and packing:—Since the grapes do not improve in colour or taste after harvest, it is necessary to be able to judge the proper maturity stage for picking. As they reach this stage, the grapes develop their characteristic ripe colour, besides the berries becoming soft. It is usual to pick out a couple of berries from a few bunches to see if they are really ripe and ready for harvest, especially during the initial stages of harvest. A sorting of the bunches is done after the harvest so as to reserve the less mature bunches for distant markets and the more mature ones for local sales. Snipping off the stalk of the bunches with a pair of clippers and handling the fruits only by the fruit stalk are important precautions to be taken, in order to reduce wastage. Careful handling of the grapes at all stages is essential not only to prevent damage but also to avoid the shedding of berries from the bunch. Rotting of the fruits may also result if the harvest is done after a heavy dewfall or rains.

Grapes are best packed in saw or cork dust, although leaves, grass, wood wool etc., are also in use. Baskets, earthen pots and crates are used as containers. Recently an improved basket packing has come into use in Madura side. To the ordinary basket of the type used for Sathgudi oranges, a protective wooden cover is provided. The protection comprises of a number of wooden reapers nailed together to give a frame-work outside the basket. The reapers are easily detachable for use over and over again. With a perishable fruit like the grape, the work of designing a cheap but yet sound method of packing becomes important.

Products:—Raisins, unfermented and fermented grape juices, vinegar and jellies are the common products prepared out of grapes. Wines of good quality have been prepared at Pattiveerampatti by a leading grower, but in view of the policy of prohibition in the country this venture has not been pursued further. Raisins can be manufactured from Kishmish, but the production at present is yet too small even to meet the demand of the fresh fruit markets. The same reason prevents any other product industries to be developed till after the South Indian viticulture is extended.

The Kishmish grapes packed in saw dust are reported to have kept well in cold storage at a temperature of 32° F. A very rough idea of the cost of production of grapes and of the margin of profit in Pattiveerampatti of Madura district can be gained from the following figures furnished by a leading grower of that village in 1946:

1. Total cost of production per acre per year in a bearing vineyard	Rs. 6,000
2. Receipts from the first crop	Rs. 7,000
3. Receipts from the second crop	Rs. 4,000
4. Net income for the year	Rs. 5,000

While it is difficult to verify the above figures, it serves the purpose of indicating that viticulture in the village is an industry of immense possibilities and requiring much capital and whole-time attention.

PESTS AND DISEASES

The following notes have been compiled from the Bulletin No. 7 (1939) of the Madras Department of Agriculture.

Pests—(1) THE LEAF-ROLLER (*Sylepta lunalis*):—This is a yellowish green caterpillar that rolls up leaves and feeds on the green matter of the leaves from within. When full fed it pupates in a cocoon inside such leaf-rolls. It is a pest that is sometimes found in large numbers. It can be checked by a systematic hand-picking of the early attacked leaves. If found in large numbers, it can be controlled by spraying with lead arsenate. It is, however, usually subject to attack by parasites which naturally bring it under control in the long run.

(2) COCKCHAFER BEETLE (*Adoretus* sp.):—At certain parts of the year—usually after the first heavy rains—large number of these beetles appear and attack the leaves at night. Sometimes wholesale defoliation may occur. During the day the beetles usually hide in the soil at the base of the vines, but come out for feeding at night. They may therefore be looked for in such situations and hand-picked and destroyed. As the beetles appear in huge numbers all at one time, it is necessary to make the leaves distasteful to them, if the plants are desired to be saved. A spray of a deterrent like Bordeaux mixture mixed with a small dose of lead arsenate will serve the purpose. Hand-picking though more expensive is said to be preferred by some growers.

(3) GRAPE-VINE SPHINX (*Hippotion celerio*):—This is a stout greenish caterpillar with a horn at its hind end, and which sometimes attacks the leaves but may easily be checked by hand-picking.

(4) THE GRAPE-VINE BEETLE (*Scelodonta strigicollis*):—This is a small blackish insect with bronzy patches on its wing covers. It usually attacks the leaves, biting holes into them, but specially damages the shoots that appear on the pruned vines. The beetles may be controlled either by hand-picking or by spraying with lead arsenate. At Nasik in Bombay Presidency, it is reported that it is usually controlled by the cultivators in the following way. Dry sheaths of banana are torn into shreds and tied into tassel-like bundles, which are placed on the pruned ends of vines towards evenings. The beetles are generally found taking shelter under such tassels at night, and in the morning can be shaken out into a basket and destroyed.

(5) THE LEAF-MINER (*Phyllocnistis toparcha*):—The small caterpillar mines in the tissues of leaves and may cause them to dry up. It is a minor pest, easily controlled by hand-picking infested leaves.

(6) THE VINE-GIRDLING BEETLE (*Sthenias grisator*):—Sometimes the vines are found girdled by a thick-set brown beetle, about three-fourth of an inch in length, the result being that the portions above the part cut, wither and dry up. The beetle lays eggs under the bark in the twig thus cut, and its grubs burrow into and develop in the dried twigs that drop to the ground. Besides the grape vine, this beetle is also known to attack the mulberry, rose, *Erythrina*, etc. The beetles which can be easily spotted should be looked for and hand-picked. The dead twigs contain the grubs and should, therefore, be collected and burnt.

(7) THE VINE SCALES (*Aspidiotus sp.*):—The buds on the vines are found in many cases infested by small circular scales, which often have the effect of preventing the new shoots from emerging. When the infestation is bad the vines may even dry up. The affected portions should be cut out and burnt at the time of pruning. The scales on the twigs may be tackled by a thorough spray with either crude oil emulsion or fish oil resin soap.

(8) In addition to the insect pests noted above, mites (*Paratetranychus punicae*) are seen in large numbers during certain seasons of the year, especially when tender leaves appear on the plant. These suck the plant sap, as a result of which the leaves dry up and the yield of the plants gets reduced. Dusting with flowers of sulphur is very effective against the pest.

Diseases —(1) DOWNY MILDEW (*Plasmopara viticola*) :—The disease appears in the cold season and has been noticed in Coimbatore, Dindigul and Krishnagiri.

The disease manifests itself by the production of irregularly shaped spots on the leaves. The upper surface of these spots is at first yellow turning red later on; while the under surface is covered with a white downy growth of fungus. As the disease advances the affected leaf curls up, withers and falls. The fungus may also be present on very young shoots, flowers, and young berries. If infection takes place at an early stage, growth ceases and the berries remain small, or shrivel up and die. Continued moist and warm conditions greatly favour the spread of the disease.

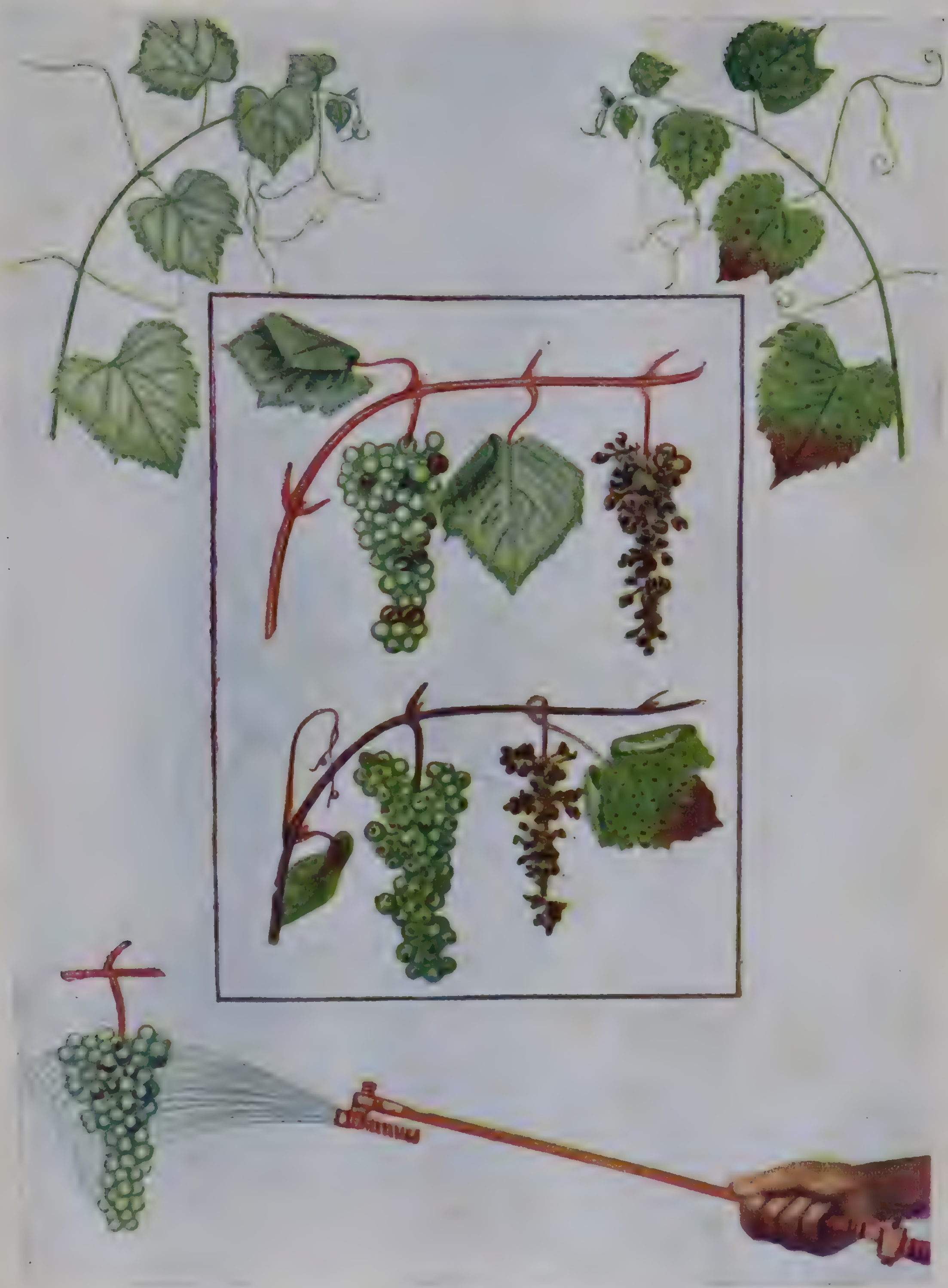

PLATE VIII. DOWNY MILDEW ON GRAPE VINE
(Courtesy of Govt. Mycologist, Coimbatore)

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The loss caused by the disease is dependent on many factors and occasionally is very severe. Removal and destruction of all diseased leaves, tendrils etc., and spraying one to two per cent Bordeaux mixture are the preventive and control measures.

(2) POWDERY MILDEW (*Uncinula necator*):—In South India this disease is more common than the downy mildew, though less harmful or destructive. The disease is characterized by powdery growth of fungus on shoots, leaves, flower clusters and fruits. Young affected shoots and leaves shrivel up and die and affected flowers fail to set. When fruits are involved, they cease to grow, crack and decay or remain hard and sour. Removal of all badly diseased leaves and systematic dusting with sulphur of 200-300 mesh or spraying with Bordeaux mixture are suggested as the treatments. The former is more effective. Spraying to be effective should be done before the disease appears, and repeated at intervals till the fruit is ready.

(3) ANTHRACNOSE OR BIRD'S EYE DISEASE (*Gloeosporium ampelophagum*):—The disease attacks all parts of the vine above ground and is characterized by brown black-bordered, sunken spots on the stem, leaves and fruit. The spots are small at first but gradually become bigger and form large lesions. The lesions have a pale central core surrounded by a brown border, with a purplish ring in between.

The disease is controlled by repeated applications of lime sulphur or dusting with fine sulphur. An acid solution of iron sulphate has been found effective in some places.

A variety known by the name of Lukfata, having vigorous growth with coarse leaves has been found to be immune at Kodur to powdery mildew, while another variety, White Muscadel, has shown to be immune to downy mildew at the same place. Both these however are poor yielders and of low fruit quality.

List of References.

1. Agricultural Marketing Adviser to the Govt. of India—Report on the Marketing of Grapes in India and Burma, 1940. Marketing Series No. 20, Manager of Publications, Delhi.
2. Naik, K. C.—Future of the Indian Grape Vine Industry. The Gardener, Vol. III, 3, 1939.
3. Naik, K. C. and K. M. Thomas—Cultivation of Grapevines—Madras Agricultural Department Bull. No. 7, 1939.

2. FIG (*Ficus carica*)

Fig has been classed as a fruit of the warm temperate zone, but from the performance of some of the cultivated varieties in South India, it seems clear that good crops of fig can be raised under all the diverse conditions of South India, provided the suitable varieties are chosen for each tract. Fig cultivation, however, has hardly made much appeal to the South Indian ryots except in home-gardens or on a pseudo-commercial scale, the reason being the perishable nature of the fruit, the considerable amount of care necessary to achieve success in its production, and the absence of any organised industry for the manufacture of dried, preserved or canned figs. At present, therefore, the fig production is limited to only a few orchards close to urban areas, in tracts which possibly afford the best of climatic conditions for the fruit. Such small-scale orchards are found near Bangalore and Seringapatam and in a few places in Bellary and Anantapur districts, although stray trees producing good crop loads are also met with all over the hills and plains of the province. Accurate figures of the acreage and production are unavailable for South India, but it is estimated that the area under this fruit may not exceed 250 acres.

Climate and soil:—Generally speaking a dry locality seems best for the fig, provided there is ample water supply for the crop to grow and mature fruits successfully. Dry atmospheric conditions are believed to be specially necessary at the time of fruit development and maturity. The soil best suited to the fig seems to be that of medium to heavy nature, retentive of moisture but well-drained, even though good crops have been secured even on less open soils well supplied with manures and moisture. Like most fruits, the fig also will benefit when sheltered from strong winds.

Varieties:—As in many other fruits, varieties are not standardised in fig. Many varieties have acquired local names, some of which are not recognisable even in the places whose names the varieties bear. For instance a variety goes by the name of Coimbatore in Western India, but no such variety exists in Coimbatore itself. In the Hessarghatta collections, Bezwada, Ganjam and Bangalore are the names of some so-called varieties. There seems little doubt that the distinction between some of these at least is not such as to accord them varietal status. The species that goes in Bangalore by the name of *Ficus palmata* is also one which may need its specific status to be looked into and re-examined. Of the

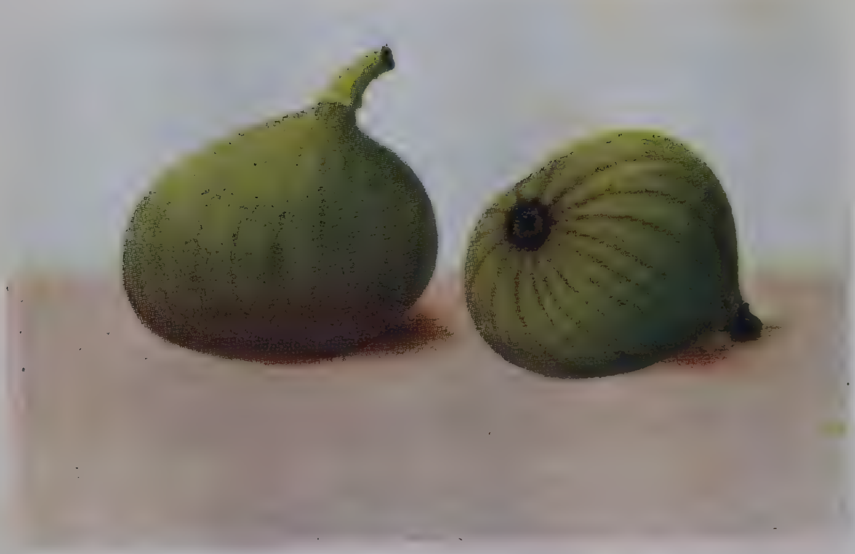

PLATE IX. POONA FIG

(To face page 385)

more widely accepted varieties, the following seem to deserve mention:

(1) *Poona*:—This is the most prolific variety on the plains and produces medium-sized, light purple fruits with uneven shoulders. The fruits are thin-skinned, sweet and well flavoured, possessing a rosy flesh.

(2) *Marseilles*:—This has been found to crop well on the hills over about 5,000 feet elevation. The fruits are pale green on the rind, sweet and medium-sized with whitish flesh.

The bluish-black fruited Black Ischia as well as the copper coloured and pear shaped Brown Turkey have also been tried with less success than the Poona on the plains. On the West Coast, *Ficus Roxburgii* produces fairly large crops of brick-red coloured fruits, which are only of poor quality.

Propagation:—Like the grape, the fig is commercially propagated by cuttings, which are generally taken from mature one-year-old wood during a dormant season. Each cutting is about eight inches long and one-half to three-fourths of an inch in diameter, but even longer cuttings are occasionally planted. To prevent the drying out of the cuttings at the tips, it is customary in some parts to apply a small quantity of cow-dung over the upper cut soon after the cutting is prepared. Six months to a year after the cuttings are planted in flat nursery beds, they are lifted out for setting in their final orchard sites. A few growers also plant the cuttings direct on the orchard sites.

In shallow soils and neglected plantations it is also possible to find several suckers arising near the stems; and these suckers can be lifted out as fresh planting material. Layering of the fig is also easy, and some growers in Anantapur district prefer to raise the layers instead of cuttings, for reasons which do not seem clear. Side-grafting of the fig on other species of *Ficus* is also possible and has been attempted with success on *F. glomerata* and *F. hispida* at Kodur.

Planting:—The planting of rooted cuttings, layers, suckers or grafts can be done from June to January, although August-September are usually favoured. There is no uniformity in the spacing given for the fig. Many growers at Bangalore adopt a spacing of six to nine feet only from tree to tree, while in

Anantapur and Bellary districts about 12 feet spacing is more common. Both these spacings are far less than those adopted in most other fig-growing regions, where 15 to 25 feet is usually recommended. The closer spacing adopted in South India are, however, suitable for the particular type of training followed in that region.

Training and pruning:—The fig is trained into a bush in Mysore State. This is done by heading back the plant every year, commencing from the first year after planting, to about two buds in each shoot of the previous season's growth. This severe heading back results in a crop of new shoots which produce the crop. The time for the pruning is January-February in many plantations, so as to secure the mature crop in the following July to October. Some growers prune the trees in October also to obtain ripe fruits in the following summer, when the price for the fruits is generally heavy. Such systematic pruning is rarely done in Madras presidency, where the plants are largely left to themselves excepting for an occasional removal of dead and wrongly placed limbs, and the pruning given at the time of separation of layers. In such cases, the fig is liable to produce long leader shoots at different parts of the tree, each with naked non-fruiting wood over considerable lengths. The unpruned fig tree is mis-shapen and is often an uneconomic performer. No attempt is being made to induce fruit-bearing wood formation at the naked parts of the long shoots by recourse to notching. Notching has been suggested by workers at Poona so as to produce fruit-bearing shoots in the places required and is done in July by giving slanting cuts over dormant buds to remove a small slice of bark. About two buds on a branch are recommended to be notched. Notching is also of value in filling blanks on trees, wherein long leader shoots stand prominently naked, throwing the tree out of shape and leading to fruit production only in a few parts. Work to evolve a satisfactory method of training and pruning the fig to build up a strong frame-work on which fruiting wood is evenly distributed, seems necessary. Such work will also entail a study to determine if the annual and severe heading-back as practised in Bangalore, cannot be replaced by a less severe treatment.

Culture:—Some of the best crops of fig are being secured in places where the crop is raised with sewage effluents. Where such facilities do not exist, heavy manurial applications are given to the crop once or twice a year. In the latter case, the applications are made once, in July to September and again, in January-February. If only one application is done, the former period is usually preferred. The quantity of manure as well as the kind of manure varies from orchard to orchard, but two to ten baskets of well-rotted cattle manure may be taken to be the range for full-grown tree of bearing age. Where sewage effluents are available, no manure is applied. In parts of Anantapur district, water supply to fig gardens being limited, the growers apply water by hand once in two to four days. Elsewhere, the intervals are greater and may extend to about four to six days during the summer and 10 to 15 days in the rest of year, except during the rains, when irrigation becomes unnecessary. Intercropping of the fig plantations is impossible as in grapes. In order to keep down weeds, soil digging is done at least twice a year at the time of manurial applications.

Caprification:—The fruit of the fig (syconium) consists of a hollow receptacle having the flowers on its inner lining. The edible part is the fleshy meat of the receptacle and the pulpy mass which develops around the flowers. There are three kinds of flowers in the fig—the pistillate or female, the staminate or male and the gall flowers. All these are not found on the same tree, but different classes of figs are characterised by different flowering systems. All edible figs are said to have female flowers but some require pollinators, while others do not. The male flowers are borne near the eye of the capri figs or, as they are called, the male figs. The gall flowers have been described as modified female flowers with hollow and stubby style and broad and flattened stigma. They are borne on the lower half of the receptacle of the capri fig. Based on the kind of flowers and on the need for caprification or pollination, figs have been classified into four groups, viz., (1) *Capri figs* whose gall flowers harbour the larvae of a wasp known as *blastophaga*, and can be distinguished by their short-styled flowers, (2) *Common figs* with long styled female flowers requiring no pollination and therefore are parthenocarpic, like the seedless oranges, papayas or grapes, (3) *Smyrna figs* which have long styles but require pollination, and (4) *San Pedro figs,* whose flowers in the first crop are similar to the common fig, while those of the second crop are like those of Smyrna figs.

For those varieties which require artificial pollination, it is a practice to suspend wild or capri figs on the trees when the young fruit of the former is one-half to three-eighth of an inch in diameter. From the latter flowers, numerous *blastophaga* wasps emerge and enter the eyes (ostiole) of the latter flowers, and cause the fruits to set. Insertion of a wooden needle through the eye of the wild *Ficus glomerata* or capri fig and then passing the same tip of the needle through the eye of the cultivated fig which requires pollination, has also been found very effective at the Fruit Research Station, Kodur. If either of these methods is not done, the flowers of fig of such non-parthenocarpic or self-unfruitful varieties turn yellow and drop off. It is, however, reported that parthenocarpy is favoured or inhibited in a given variety under different climatic environments. Poona, Black Ischia and Brown Turkey varieties have been found to be parthenocarpic at Kodur, while Turkish White variety has failed there to set crops without caprification or the stimulus of artificial pollination.

Cropping:—One-year-old rooted cuttings or large layered plants sometimes produce a crop even in the first year of planting, but it is only after the third year a fair crop outturn may be expected. In South India on the plains the fig produces two crops a year, once from July to October and again from February to May. Some fruits can also be seen on the trees in October-November, but these do not mature, and are therefore best plucked off and thrown away. The summer crop, being of superior quality and more valuable in the markets, some growers in Mysore State specially prune the trees in October to secure larger yields in the following February to May. In Anantapur and Bellary districts where no systematic pruning is done, the trees yield crops in both seasons. At Poona it is found that the first crop maturing in March to May is only gathered for sale, while that from July to August is plucked off as unfit for sale.

The yield per tree in Mysore State has been estimated at 15 dozen fruits per year. On unpruned trees, however, by far heavier yields have been gathered. Between varieties there seem to exist appreciable differences. In a young plantation at Hessarghatta *F. palmata* gave a mean tree yield of 360 fruits as against only 76 fruits in Bezwada. In Bellary and Anantapur districts, where the spacing is greater and trees are larger because of no pruning, the mean tree yield per year is higher, being in the neighbourhood of 300 fruits. On an acre-scale the yields are not likely to differ greatly between the above centres. After about ten years of planting, the unpruned trees at Bellary and Anantapur districts seem to show a marked decline in yields.

Ripe Poona figs are reported to have been kept well in the cold storage at Poona for a month only at 32° and 35° F.

Pests and Diseases:—Much work has not been either done or reported upon on these subjects. The only one minor disease reported by the Govt. Mycologist, Madras is Rust (*Uredo fici*), which causes minute, yellowish brown pustules to be found on the lower surface of leaves. In severe cases the leaves drop away and yield declines. Dusting with fine sulphur (300 mesh) has been recommended. As for pests, none has been reported as causing any great loss to the fig, excepting for some loss due to some birds and animals attacking the mature fruits on the trees. Some growers prepare special tin covers for each fruit to prevent the damage, while others believe that the damage can be localised and lessened if the first attacked fruits are left on the trees unpicked.

Wild Fig:—*Ficus glomerata* is an allied tree found in most parts of the province and enjoying some popularity as an avenue tree. It yields edible fruits in great abundance. Work at Kodur has shown that the fruit of these can be dehydrated to yield a useful powder, which can be employed for preparing an excellent cold jelly. When malted and roasted, the powder also gives a valuable breakfast food, almost similar to the imported "Grape Nuts" sold largely in Indian markets.

List of References

1. Naik, K. C.—Fruit Personalities—Fig—*Mezhichelram* (In Tamil), Madras, January, 1946.
2. Rao Subba, C. K. Rao Bahadur.—Notes on Fig Cultivation in Southern India and Peculiarities in Viticulture in Penukonda in Anantapur District. Vol. III, Bull. No. 57, Madras Agr. Dept. 1908.

3. **POMEGRANATE** (*Punica granatum*)

The fruit of the pomegranate has for a long time past enjoyed a reputation in India for its healthful dietetic and medicinal properties. It is also popular with a section of the people for its sprightly flavour. As a decorative fruit on the table, it has a few equals. Many persons prize the cooling syrup or squash made from fresh pomegranate fruits.

Climate and soil:—The pomegranate has been classed with the date palm in regard to the climatic requirements, both being considered to require a cool winter and a hot and dry summer. Experience of pomegranate cultivation in South India points out the greater adaptability of this fruit than that of the date palm. While the former is found to grow and fruit well all over the plains and even on the hills up to an elevation of about 6,000 feet from the mean sea level, the date palm is found to grow only on the plains. Despite the wide range of conditions under which the pomegranate grows in South India, it is found to be only a crop of little commercial importance, so that the total area under it is hardly above 100 acres. Like the fig it is more popular in home-gardens rather than in commercial plantations, the exception being in a few areas in Uthukuli village in Coimbatore district, near Vellodu and Dindigul in Madura district, near Penukonda and Madakasira in Anantapur district, and in Madhugir in Mysore State. It seems well-adapted to diverse soil types, though heavy loams are probably preferable. There is also some evidence to suggest that better quality fruits are obtained in places where warm and arid atmospheric conditions prevail during the fruiting season and where the soil is not very light or sandy. The splitting of fruits which is a common feature even in younger stages of fruit development in some parts, is believed to be an indication of the unsuitable climatic conditions. Commonly considered as a hardy plant, the pomegranate, however, is often neglected in home-gardens and is often relegated to the most infertile nooks in orchards and sometimes even to the live-hedge rows.

Varieties:—Leaving aside the white and double-flowered ornamental types which produce mainly sterile flowers, the pomegranate as a cultivated fruit plant is largely distinguished among its several varieties by the shape of fruit, colour of its rind, the taste and colour of its arils, and the nature of seed. The fruits are round, oblate or obovate in form; the rind may be thick or thin and varies in colour from pale yellow to deep purple red; and the arils or the small berry-like fruit bodies inclosed in their membranes inside each locule are transparent and vary from crimson to pale yellow. They also contain seeds of variable size with seed coats of varying degrees of hardness, some of the softer seeded varieties being popularly known as "seedless".

Of the numerous varieties grown in South India, the following have been adjudged as the most promising at Kodur.

1. *Paper shell*:—This is a prolific variety, producing medium-sized fruits with thick skin, medium to large seeds, which are softer than others. The arils are reddish to pink in colour and possess abundant juice: flavour good.

2. *Spanish Ruby*:—This is also prolific, bearing small to medium fruits. Skin is thin, arils rose coloured and juicy; seeds small to medium in size and soft: quality medium.

3. *Musket Red*:—Moderately prolific; producing small to medium-sized fruits. Skin is either thin or moderately thick, seeds soft; arils juicy, and moderately sweet.

4. *Vellodu*:—Moderately prolific, producing medium to large-sized fruits: skin moderately thick; arils juicy and good in taste; seeds medium in size and moderately hard.

Propagation:—Curiously enough, the pomegranate is raised mostly from seed in South India, unlike in other countries. Seedling trees are found to differ widely in tree and fruit characters. Vegetative propagation is therefore found to be a more dependable means of preserving and multiplying the selected varieties, and this deserves to be substituted to seed propagation. The almost universally popular method is to raise this fruit by hard wood cuttings. About 10 to 12" long cuttings of the past season's growth are selected, and these are planted in open beds leaving only one or two buds exposed. A year after this, the rooted cuttings can be lifted out with a ball of earth around the roots of each plant and set out in the orchard. Layering is possible, but this is seldom done.

Planting:—Like most other plants the pomegranate is planted from July to January, the early period of the monsoon season being usually preferred in tracts subject to low rainfall. In most orchards the spacing given varies from 15 to 20 feet, although as low as six feet spacing is not unknown in some orchards and particularly in home-gardens.

Pruning:—Fruits are borne on the pomegranate terminally on short growths emerging from mature wood. Every year the bearing region is progressively pushed farther away from the base. In old trees little fruit is also found in the interior of the trees. It has therefore been suggested that, for securing shapely trees and good performance, a crop of new shoots should be encouraged every year on all sides of the tree; and such new growths should be made to flush out from one to three-year-old wood. Since severe heading-back of old wood is undesirable, the pruning should be done annually and confined to the shortening of the past season's growths. The unpruned tree of the pomegranate usually presents a scraggy and ugly appearance with numerous willowy branches crossing each other and with numerous suckers arising from the base, and thus forming multiple stems. The pomegranate exhibits a strong suckering habit in the orchard and every care is necessary to suppress this habit. The fruits on such unpruned trees are restricted to only a few outside branches, from which they hang down at the tips. In order to have single-stemmed, shapely trees with strong frame-work, frequent removal of suckers and misplaced branches is essential; and this has to be commenced from the very time of setting out the tree in the orchard site. Annually thereafter the past season's growths should be shortened to an inner or outer bud, so as to regulate the top, at the same time thinning out the congested parts. If these are done carefully, it is easy to regulate the crop evenly on all sides on a strong frame-work.

The orchard culture in so far as the pomegranate is concerned does not seem to call for any comment.

Cropping:—Strong rooted plants have been known to fruit even in a year of planting, but normally the pomegranate commences fruiting in the orchard in two and a half to three years. Although the fruits are available all the year round, peak harvests at Kodur are secured in about June. On pruned trees of six to eight years of age, the mean tree yield is estimated at about 50 fruits, with the maximum at 150 fruits in a year. It is believed that the failure of several flowers to set fruits is due to the fact that varying proportions of flowers in the pomegranate are sterile. The pronounced tendency of the pomegranate to bear a large number of split fruits is also a cause for reduced yields. The extent of such split fruits, however, seems prominently conditioned by the environmental factors, the loss being more in some areas and in some years than in others. It is also believed that the loss gets reduced as the trees age, and as the influence of sheltering tree belts in the vicinity begins to be increasingly felt. Possibly, the varieties also differ to an extent in their response to weather or environmental conditions, and consequently in their ability to carry the fruits in a sound condition to the maturity stage.

The fruit of the pomegranate is attached tenaciously to the fruiting wood, which necessitates the clipping off of the fruit stalk at the time of harvest. The practice of pulling off the fruit by hand is undesirable, as this may cause injury to the fruit, besides leaving on it an ugly piece of stalk with capacity to cause further injury to the fruits packed along with it.

The pomegranate is reputed to keep well after harvest. Some varieties are specially reputed for long storage qualities and remain in edible condition even long after the skin dries and hardens.

Birds, bats and squirrels are fond of the fruit and may cause severe damage to pomegranate crops. A system of enclosing each fruit in a wire cage, specially made to suit the fruit size and can be kept in position with the aid of a hook fastened around the fruit stalk, is prevalent in some parts.

PESTS AND DISEASES

PEST—1. FRUIT BORER (*Virochola isocrates*):—The caterpillar of this butterfly lays eggs on the flowers or tender fruits, and the larvae bore into the fruits. It is a wide-spread pest, causing considerable havoc all over South India. The damage can be greatly prevented if the calyx cup of the flowers are clipped off at the blossom end as soon as the fruit is set, in order to prevent the egg laying by the pest. The treated fruit may then be enclosed in a paper or cloth bag. A spraying with calcium arsenate (1 oz. in four gallons of water) may also be done as a further precaution. The attacked fruits should all be destroyed and the butterflies may also be caught with the aid of hand nets.

DISEASE—1. LEAF AND FRUIT SPOT (*Cercospora* sp. and *Gleosporium* sp):—These cause tiny, circular, brownish spots on leaves and fruits. The affected fruits also rot later. Spraying with one per cent. Bordeaux mixture is recommended.

List of Reference

1. Naik, K. C.—Fruit Personalities—Pomegranate—*Mezhichelram* (In Tamil), Madras, May, 1945.

4. LOQUAT (*Eriobotrya japonica*)

Also known as Japan plum or Japanese medlar, this is a popular fruit in China and Japan, but the varieties so far cultivated in South India are hardly such as to make any appeal to the South Indian palate. The tree is, however, grown mainly for its ornamental value in some parts of the province up to an altitude of

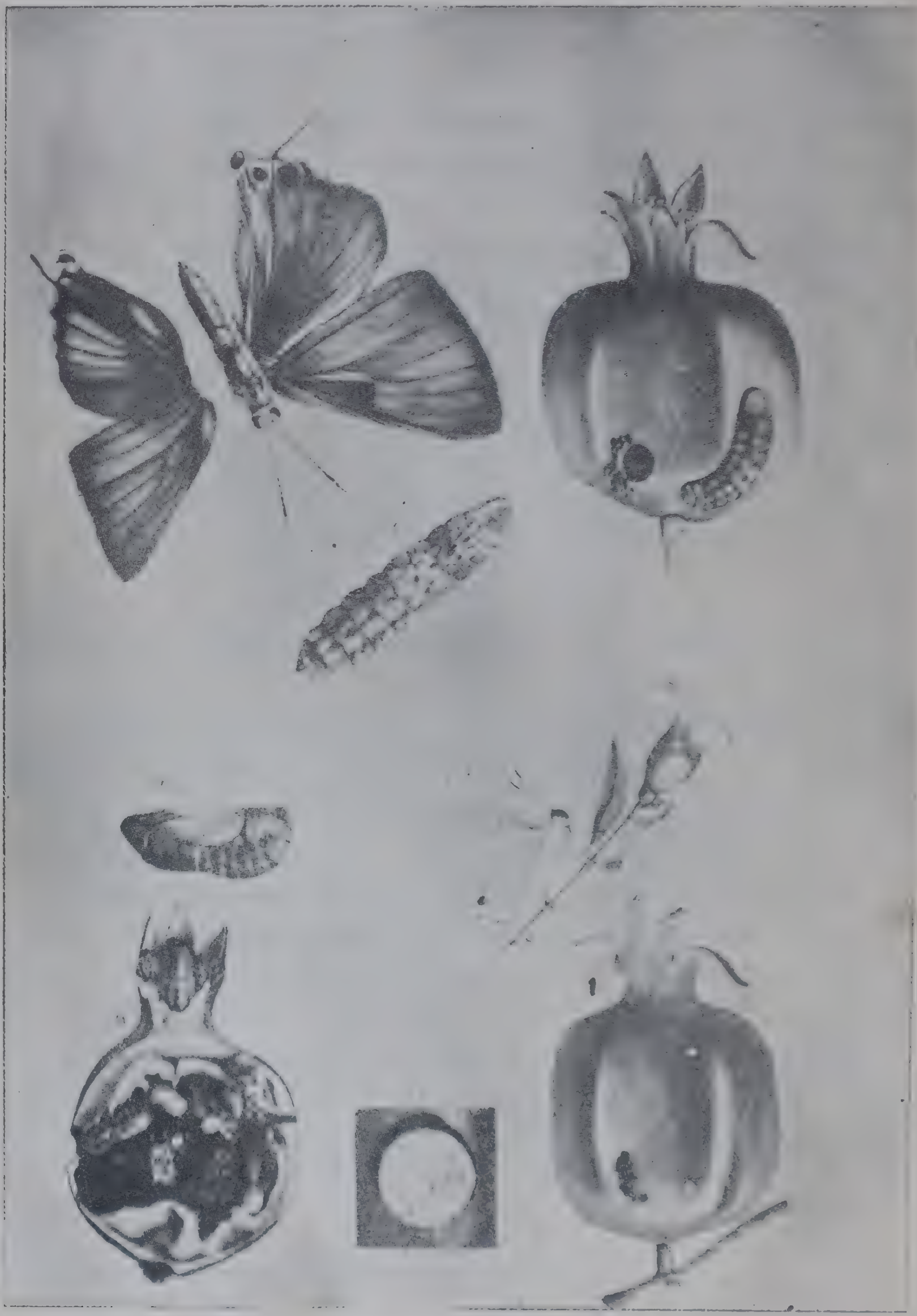

Fig. 99. Pomegranate butterfly pest
(*Courtesy of the Govt. Entomologist, Coimbatore*).

about 6,000 feet. There are several varieties, but none of the few introduced in the region have been found to be very prolific. Some of the trees on the Nilgiris grown at an altitude of about 5,000 feet, though have developed into large size, crop only poorly, and some not at all. A few grown on the Lower Palnis and Nandi Hills seem to have fared better in these respects. The loquat is propagated by seed in South India, and this probably accounts for the poor types of trees in the region. Grafting and budding on seedling loquats and quince have been employed elsewhere but are yet to be tried in South India. Layering is also found possible at Kodur. The trees are usually spaced 30 to 35 feet apart. The fruits are used for dessert purposes as well as for making jelly and preserves, and are borne in clusters. The varieties existing in South India are generally acidic and poor-flavoured, and possess either white or yellow flesh. As birds seem to be fond of the fruits, the fruit clusters have to be enclosed in paper bags. A mature tree may yield 20 lbs. roughly per year from March to June, but on the Lower Palnis the harvests are said to range from August to September. The trees flower in July-August at Kodur and sometimes in January, but the former flowers usually shed. On the Nandi Hills in Mysore State, flowering was observed in June at an elevation of 4,850 feet and the fruits are said to ripen in the following August.

CHAPTER VI

HUMID ZONE FRUITS.

Introduction:—It may appear that the term "Humid Zone" is strictly inapplicable by itself to the tracts to which they are intended to apply, nor to the fruit crops proposed to be dealt with under that zone. There is certainly much force in the argument that the plains of the West Coast of South India, which enjoy very heavy rains generally exceeding 100 inches per annum, possess as high humid atmospheric conditions as those on the lower slopes of the Nilgiris or Palnis, if not more, in certain periods of the year. The high relative humidity enjoyed by the latter is partly also due to the thick vegetation and the peculiar topographical considerations. At any rate, these tracts are relatively cooler than the plains of the West Coast, because of the fact that higher elevations serve to temper the heat on the hill slopes. Notwithstanding the foregoing considerations, the caption is allowed to be retained, since it serves on one hand, to distinguish the conditions prevailing on the hills and the arid plains and on the other, makes it convenient to group such fruits as mangosteen, durian, litchi, rambutan, langsat, *Monsteria deliciosa,* avocado pear and the loose jacket orange under one zone. None of these fruits are found to flourish on the heavy rainfall areas of the plains of the West Coast, possibly because of the higher ruling temperatures there. The loose jacket orange, however, has already been dealt with separately under the group of Citrus fruits; and the rest are reserved for treatment under this chapter.

1. MANGOSTEEN (*Garcinia mangostana*)

Few fruits can compare at present in universality of their appeal to all sections of the people as the mangosteen. Acclaimed on all hands as one of the most exquisitely delicious table fruits. the mangosteen is no less prized for its attractiveness as a table fruit than as a graceful tree in the orchard or home yard. South India enjoys at present the virtual monopoly for the production of this deservedly reputed fruit, and there is no doubt that the region will find it to its advantage to extend the area under it. With the good keeping quality of the fruits, the mangosteen can stand transport well to any of the various markets of India, and find a ready sale too. This together with its tendency to produce heavy crops should prove an incentive to extensive culture of this

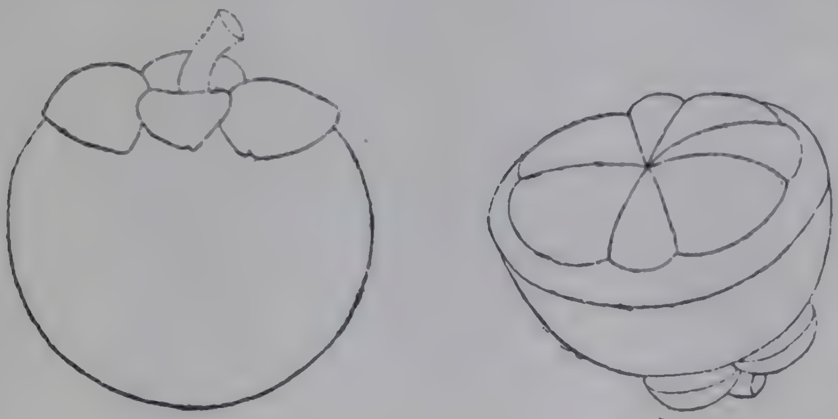

Fig. 100. Mangosteen fruit—whole and in transverse section.

fruit, despite some of the disadvantages such as the long pre-bearing period and the difficulties in transplanting young trees to new sites.

Climate and soil:—At present the mangosteen is grown only on the lower slopes of the Nilgiris between an elevation of 1,200 to 3,500 feet and near Courtallam in Tinnevelly district. The total area is not likely to exceed 25 acres in South India. From performance of the trees in different orchards it seems possible that the fruit will thrive in Wynad, Anamalais, slopes of Lower Palnis and on all hills and hill slopes from about 1,200 to 3,500 feet in any part of South India, provided the annual rainfall is about or more than 50 inches and the sites are well sheltered by thick belts of vegetation. Attempts made to grow this fruit in the plains of the West Coast have proved unsatisfactory, possibly because of the higher temperatures and long periods of arid atmospheric conditions during the non-monsoonic times of the year, such as from October to June. High summer heat combined with dry atmospheric conditions seem to make the trees and fruits ooze out gums, causing a high incidence of the gambog disease. A rich loamy soil of good drainage but with ample soil moisture supply is also believed necessary for the success of the crop.

Varieties:—There are no varieties in mangosteen. The trees are believed to set fruits without the aid of cross-pollination, and consequently variation in seed progeny is never known. Besides, the mangosteen is also slightly polyembryonic, which serves to produce plants from nucellar embryos, all of which resemble the parent in all respects.

Propagation:—The most common method of propagation is by seed, but since the seedlings attain the bearing stage after eight to ten years of sowing, much work has been done to devise a vegetative propagation method that would lead to a more precocious performance. On the basis of work on the varied aspects of propagation as carried out at Kallar and Burliar fruit stations, it is now possible to offer some guidance on the nursery practices. For seed propagation, it is now known that healthy, pulp-free seeds, extracted from ripe fruits and sown within five days of extraction, provide the best seed material. Such seeds not only produce the highest germination (up to 70 per cent) but also produce the most vigorous seedlings. Seeds from gamboged fruits also do germinate to an extent, and even better than those healthy seeds which are sown with pulp intact. However, the seedlings from gamboged seeds appear sickly and weak at the initial stages and are therefore unlikely to provide the best planting stock. The seeds sown more than five days after extraction rarely germinate, while fresh seeds free of pulp have recorded an increase of about 20 per cent germination over those sown with pulp intact. Since the mangosteen is an expensive fruit, and the number of seeds per fruit varies from nil to two only, the foregoing facts are of practical interest in securing the largest number of seedlings at the minimum of cost.

Trials with different media for sowing have also shown that peaty soil is the best for the mangosteen seed, being better than sandy loam, or common garden soil, or the common pot mixtures.

From a count made in a batch of 384 seeds, it was found that mangosteen exhibits polyembryony to an extent of about 5.5 per cent. In other words, 21 extra seedlings were obtained from the germinated seeds in the above mentioned sowings, with a total of three seedlings being the maximum per seed. At Taliparamba, in 1945-1946, six per cent. of the seeds developed two seedlings each per seed. While it is impossible to separate the individual embryos before the seeds germinate in mangoes and citrus, it was found that the nucellar embryos could be easily separated in the mangosteen after removing the aril and the thin covering underneath.

Considerable attention has been bestowed on the vegetative propagation of mangosteen at the Kallar and Burliar fruit stations. The work has proved that side-grafting of mangosteen on seedlings of the same fruit is easy and capable of producing almost a cent per cent. "take" in an optimum season. However, the successful side-grafts have uniformly failed to make any appreciable growth in orchards, while most of them can be hardly established in orchard sites. Side-grafting *in situ* in the final orchard site, has fared no better, so that at present it is difficult to recommend this method for commercial nurseries. It should, however, be possible to devise improvements in nursery and planting practices such as to secure more encouraging results with the side-grafts, which being very easy in operation, hold out still great promise for the future. In this connection, pre-hardening of the side-grafts under dense shade seems important. Such shade may also be necessary in the case of plants side-grafted *in situ.* Side-grafting on *Calophyllum inophylum* has also shown to be possible, although the scions make slow growth after the union. Budding of the mangosteen is less encouraging, since the inserted buds "take" poorly, and even after showing signs of union with the rootstock, may take long to sprout out. Among the several other methods tried on many rootstocks, inarching mangosteen on *Garcinia tinctoria* and *Garcinia speciosa* have given some signs of success, the maximum amounting to 60 per cent. in the grafts prepared in July-September, 1946 and separated out in January, 1947 on the former and 20 per cent. in grafts prepared in July to September in 1946 on the latter. The grafts on *G. tinctoria* rootstock aged more than four years appear to be the most promising.

Work done at Taliparamba in 1945-1946 has also disclosed that cuttings do not provide a feasible method of propagating mangosteen, even though the cuttings remain alive for nearly eight months in beds, and stray cuttings do produce one or two weak roots which, however, fail to survive. Layerings also shared the same fate. From the inarching trials, it was also noted that the mangosteen failed to show any signs of union with *Calophyllum inophylum.*

Along with the vegetative propagation trials discussed above, an attempt has also been made at Kallar and Burliar to study the nursery practices relating to the production of rootstocks of possible value for mangosteen. Seedlings of five different species of *Garcinia* and of *Calophyllum inophylum* have been raised in large numbers. These studies have disclosed that *G. tinctoria* is best transplanted from seed to nursery beds within about six months of sowing. Later, these seedlings transplant with difficulty, since they develop long tap roots which resent being cut severely at the time of lifting. Among the *Garcinia species* largely found in South India, *G. tinctoria, G. cambogia* and *G. indica* yield fruits which are edible, though of poor quality. The first grows into a handsome and robust tree capable of yielding heavy crops in many parts of South India; the second is also a large tree with drooping branches found mainly in the West Coast, while the last is a slender tree also with drooping branches and found commonly in the West Coast. *Calophyllum inophylum* also grows well on the West Coast and yields heavy crops, from which an oil is extracted. It will be interesting to try these and other allied plants as rootstocks for the mangosteen; for on its success may depend the future extension of mangosteen production in tracts ordinarily considered at present as unsuitable for the fruit.

PLANTING :—Like other *Garcinias,* the mangosteen seedlings are difficult to transplant, owing to long tap roots and poor lateral or root-fibre development. The seedlings are generally lifted with a large ball of earth around the roots causing as little injury to the tap root and preserving as much fibre as possible and are planted out under semi-shade in July-August. The spacing indicated as suitable under Kallar and Burliar conditions would be not less than 28 x 28 feet but preferably 35 x 35 feet. Transplanting of seedlings from seed to nursery beds when about six months of age may be done to harden the plants. In any case the final transplanting into orchard sites may be done within two years of sowing the seed.

CULTURE :—Natural or artificial shade seems essential for the young plants in the orchard sites at least during summer in the first year after planting. Regular watering has to be done in the same way as recommended for citrus fruits. Except for removal of dead shoots, no pruning is done for the mangosteen. Heavy organic manure applications seem necessary, although in the matter of its nutrient requirements, definite information is yet wanting.

CROPPING :—Observations made at Taliparamba have shown that the mangosteen bears its crop not on the terminals of main branches but largely on the laterals which emerge from the main branches a couple of internodes below the tip of the branch on the main axis. About 37 per cent. of the laterals and 60 per cent. of the secondary shoots arising from the laterals were found to constitute the crop in 1945-1946. These fruit-bearing laterals and secondaries are found more abundant towards the exposed parts of the tree top than near the trunk. Among the former, those situated in the middle of the main limbs or branches seemed more productive than those situated below or above this part. The new growths arise from the terminal rosette, usually about seven to eight months after flowering of the lateral, while the flowers are produced from the terminal rosette of the laterals and secondaries, which had not produced extension growth in the previous season, but which may or may not have borne a fruit two years before.

The Taliparamba observations in 1945-1946 also show that the period from flower to fruit maturity is not constant in all seasons. The yields as well as the seasons of bearing depend largely on weather conditions and possibly also on soil moisture conditions. In 1944-45 the harvest of mangosteen in Kallar and Burliar occurred from July to December and January to March; in 1943-44 the bearing seasons were from July to October and January to March; and in 1945-46 they were from July to October and December to March respectively. From an analysis of the performance of the trees, it seems that a prolonged dry weather preceding the fruit set contributes to favourable crop size. The yields of the best trees of bearing age at Kallar has averaged in a three-year period to about 300 fruits in the first season (monsoon crop) at Kallar as against the general average of about 240 fruits for the plantation, while in the second season (summer crop) the figures per tree were about 180 and 160 respectively. It seems inaccurate to call the latter as an off-season crop and the former as the main season crop, as is popularly done. In 1945-46 for instance, the so-called off-season crop at Kallar averaged to 333 fruits per tree, while the so-called main crop accounted for a mean tree yield of only 192 fruits. Khan has also proved that there is considerable variation in the bearing capacities of mangosteen trees from year to year and that, the crop size varies inversely with the amount of rainfall and the number of rainy days in the pre-blossoming period. The yields also vary to an extent from orchard to orchard, the highest recorded yields for Burliar for instance, having been 800 fruits per tree in 1944-45, as against the maximum of 520 fruits per tree in Kallar in the same year. A slightly later emergence of blossoms and some variation in the dates of maturity are also observed in some years at Burliar from that at Kallar which lies roughly 1,000 feet below.

Apart from the fruit which is relished by all classes of people, the mangosteen rind is also considered popularly as a specific against dysentery, like the pomegranate peel. Peels of other *Garcinias* also are reported to possess similar medicinal properties, due to probably the high tannin content of these peels.

PESTS AND DISEASES :—The gambog is the only serious disease confronting the mangosteen. Observations show that the gum excrescence on the shell is no indication of the soundness or diseased condition of the edible contents within. Seasonal conditions seem to exert a profound influence on the incidence of gambog disease. The crop maturing in summer and in exposed situations usually suffers more from gambog than the monsoon crop or fruits from sheltered orchards. Fruits exposed to sun's rays seems to be specially liable to be gamboged than those in the shaded parts of the tree. The large variations in the extent of gambog incidence between individual trees suggest that in tree selection there may be a means of evolving clonal strains with a high inherent degree of resistance to this physiological disorder. Since this disease seems to be largely conditioned by weather, the prevention and control seem to also lie in choosing the right situation for the fruit. Observations at Taliparamba seem to show that continuous and heavy rain with no bright weather for about two to eight weeks immediately prior to the ripening of the fruit induces gambog incidence in the West Coast. As a result, the fruits harvested in the end of June and the middle of August in 1945-46 were severely affected, while those in the rest of the year were less so or entirely free. Flowering in April-May is therefore desirable in the West Coast, if healthy fruits are desired. Protecting the fruits from direct rainfall or sun heat with paper cover served no purpose in minimising gambog incidence.

In addition to gambog, splitting of fruits also occurs in the West Coast. This is found specially after the commencement of the monsoon and increases as the season advances. The cracked fruits were found to have swollen arils, possibly due to absorption of water through the placenta, and were found to be mushy inside, but not altogether unfit for consumption. No relation was found between fruit splitting and gambog incidence.

Because of the above two maladies, it would appear that in the West Coast the monsoon rain is a limiting factor for economic cultivation of mangosteen. The successful cultivation of the crop on the plains of the West Coast, i.e., below about 1,000 feet elevation seems dependent on the successful devising of methods to induce the trees to complete the flowering by the end of April, so that the peak harvest season is either before the heavy rains occur or about two weeks after the heavy monsoon is past.

Some leaf eating caterpiliars are also observed to cause occasional damage, and these can be easily controlled by handpicking.

List of References.

1. Khan, K. Fazlullah—Crop Yields in Mangosteen as influenced by Seasonal Conditions—Indian Journal of Horticulture, 1946—Vol. IV—June-Dec., 1946—Nos. 1-2.
2. „ Some observations on seed germination in mangosteen (*Garcinia mangostana*). The Madras Agricultural Journal, September, 1947.
3. Naik, K. C.—Notes on Mangosteen Propagation—Indian Journal of Horticulture, July, 1944.
4. „ Fruit Personalities—Mangosteen—*Mezhichelvam* (Tamil) Madras, April, 1946.

2. **DURIAN** (*Durio zebithinus*)

This is a fruit little known except in the limited areas of its production. It is as popular among the few who have cultivated a taste for it as it is condemned by those who can never stand the strong odour of its ripe fruits. The fruit resembles a small jack and is covered externally with short, sharp-pointed, woody and stout protuberances. It is oval in shape and is 5-valved, with a whitish buttery flesh of a rich taste and very strong smell, extremely disagreeable and repulsive to many persons when the fruit is ripe. The tree is lofty and large. It is wise to keep off from the durian groves at the fruit maturity seasons, since the falling ripe fruits weighing on the average about five lbs. is a real source of danger to passers-by under the trees. Though grown mainly for its edible flesh, the fruit can also be salted, preserved and cooked in some ways. The seeds also are edible and can be eaten after roasting.

The total number of trees in cultivation in South India are not likely to exceed one hundred. Being a humid-tropical fruit, it is at home on rich soils with ample moisture at the roots and on sites enjoying a high relative humidity and long growing season. The trees planted along a brook at the lower extremity of the

Burliar Fruit Station are found to have put forth excellent growth and good performance. Trees planted in the West Coast along a water course and well-sheltered by thick vegetation on adjacent hill slopes have also developed into great size.

Possibly due to seed propagation, trees may produce fruits of different shape and sizes, but the trees in cultivation at Burliar appear to belong to one variety, all producing oval fruits, each about six to eight inches long and of uniform eating quality.

Preliminary trials on the propagation of durian at Burliar have indicated that inarching on durian seedling is feasible, a successful "take" of 50 per cent. having been recorded in the operations performed in January 1946 as well as in September-October of 1945. Shield-budding was also tried but with no success. The seeds should be sown soon after extraction from the ripe fruits.

The seedlings are transplanted in the orchard usually with a spacing of 30 to 40 feet, to provide enough scope for the large spread of branches of the full grown trees.

The durain fruits are borne usually after nine to about twelve years of planting the seedlings. Some trees even older than this age have been found to produce no crop in the West Coast, possibly due to self-sterility. The same feature was associated with a tree of over 18 years of age in the Kallar Fruit Station. At Burliar the durian fruits become available for harvest from July to September. The individual tree yields per year are roughly 45 fruits weighing 70 to 80 lbs.

No pests or diseases of any importance have been met with or reported from growers of this fruit in South India.

Cullenia excelsa known popularly as the wild durian is found on the Anamalais, Courtallam and the Lower Palnis but the fruits of this are not edible.

3. LITCHI (*Litchi Chinensis* syn. *Nephelium litchi*)

The translucent, juicy and often perfumed aril or edible flesh of the litchi is famed as a table fruit in Northern India, while in China and Japan it is prized in fresh, dried or canned state also. Although the ornamental trees of litchi grow luxuriantly and yield heavy crops of luscious fruits in some parts of South India, to the vast majority of inhabitants in the region litchi is yet an unknown fruit. Like the durian it is grown only on a small scale, such that the total number of trees in South India is believed not to exceed about a hundred. The tree is found to grow well both in humid hill slopes, as well as all over the plains of South India, up to an elevation of about 3,500 feet from the mean sea level. So far, however, the best performance has been secured only on the former areas, representing the conditions as those at Kallar and Burliar Fruit Stations. The litchi seems to prefer a fertile, medium to open-textured and deep soil with ample organic matter and water supply, but it is essential that the soil should be well-drained.

VARIETIES :—Of the several varieties, only six have been tried at Kallar, but all these are yet in a pre-bearing stage. The one variety in fruit at Kallar and Burliar is seeded and non-perfumed, but of good dessert quality, and is very prolific.

PROPAGATION :—Layering and gootee are the common methods of propagating litchi in most parts of the world, but grafting and budding have also been reported as possible. Seed propagation is not commended except for raising rootstocks, in view of the fact that seedling trees are very variable in fruit quality and take long periods to reach fruiting stage. Many of the trees which have been found to bear no crops on the plains of South India even for about 15 years after planting are believed to be all seedlings. Tongue or ring layering has proved to be very easy at Kallar and Burliar and has produced a successful rooting upto 100 per cent. in the layered shoots in August and September. The operation, however, seems possible from July to January with equal facility and promise. Inarching is usually done on litchi seedlings or those of *Nephelium longana* (syn. *Euphoria longana*). On the former stock a 30 per cent. "take" has been obtained at Kallar. Marcotting is also as easy as layering, though tedious; while budding, side-grafting and cuttings have failed to give any appreciable success.

PLANTING AND CULTURE:—The plants are usually set out with a spacing of 25 to 30 feet in the orchard, since the trees reach large dimensions after reaching the adult age. Like most mangoes, the tree forms a dense top with a large number of low-hanging shoots, which may be removed in gradual stages up to a height of about 18 inches from the ground. The orchard cultural practices suited to other irrigated fruits may be adopted for litchi also, till more is known on the subject.

CROPPING :—The litchi layers commence to fruit in about six years of planting. It has, however, been observed in South India that the litchi trees generally reach the bearing stage later than in the North. At Bangalore for instance no crop was borne at Hessarghatta Fruit Station for nine years after planting. At Kallar and Burliar the blossoms appear usually in about December, while in Bangalore it is reported that the trees often produce two crops in a year—in May and December, while the normal harvesting at Kallar and Burliar is done in April and May respectively. The trees produce either staminate or perfect flowers, and only a small number of the latter develop into fruits. It is possible that the failure of some stray litchi trees to crop on the plains of South India may be due to the larger percentage of male flowers or due to the inability of flowers to set crops for lack of compatible pollen parents. The individual tree yields at Kallar and Burliar have averaged to 57 and 286 lbs. in 1945-46 and 95 and 93 lbs. respectively in 1944-45. The Burliar trees are older, and this fact together with the variations in seasonal influences may have been responsible for the large variations in yield.

At the time of harvesting litchies, a portion of the fruit stalk and some leaves are retained with each cluster, as these are believed to help in longer storage of the fruit. The fruits are picked when the rind or shell colour changes to red or dark green, depending upon varieties.

Nephelium longana is a large tree found wild in Western Ghats of South India. The arils of this also are edible, though far inferior in quality to that of litchi.

4. **RAMBUTAN** (*Nephelium lappaceum*)

Like the litchi this too thrives in the humid zones as those found on the lower hill slopes of the Nilgiris. The fruits resemble the litchi, except that they have soft, crimson-coloured spines on the shell, due to which they are sometimes known as hairy litchi. The shell is greenish or yellow in colour while the edible aril is white or rose-tinted, translucent, juicy and incloses the seed as in litchi. The taste is pleasant and is preferred by some to that of the litchi. Only a dozen trees are found in South India, which is an incorrect indication of the quality of this fruit and of the scope for its production. No varieties are known in South India. The propagation is bv seed or by layering, or inarching on the same seedling rootstock. From seed there is a possibility of getting staminate and unproductive trees. Rambutan trees at Kallar do not grow to such large dimensions as those of litchi, and a spacing of 20 to 25 feet may therefore be adequate. The trees begin to crop in about six years of planting. Only the female trees are productive and these seem to set fruit by self-pollination. The individual tree yield is about 20 lbs. per year at Kallar, and the fruits are in season from September to November.

5. LANGSAT (*Lansium domesticum*)

This is grown only as stray trees in the Burliar Fruit Station. It produces a straw-coloured, oval or round, juicy fruit with aromatic taste and of one to two inches in diameter. The skin is leathery and incloses five segments of white, translucent flesh containing one to three seeds. While eating the flesh, the seeds should not be bitten, as these are bitter. The fruits are borne in clusters and are in season from April to September. The trees are propagated by seed at present. The individual tree yield at Burliar is about 30 lbs. per year.

6. MONSTERA (*Monstera deliciosa*)

This is a semi-creeping ornamental plant that can be grown particularly in humid hill slopes, in Bangalore as well as in sheltered spots all over the plains. It is commonly trained to a large shady tree. It produces flowers with a green spadix enclosed in a waxy white spathe. The spadix develops into a large fruit, which is green when immature but changes to a lighter hue when ripe. The fruit does not ripen at one time, the process starting from base upwards. The plant is propagated by stem cuttings or sets in the same way as sugarcane. Each set is made to have two or more segments or buds, and is planted horizontally where the vine is to grow. Seeds can also be used for raising plants, but this is seldom done. The vines produce fruits in two to three years after planting, and the fruits appear generally in about March. The fruit is not fit for the table when picked. It is only when the hexagonal scales fall off, that the fruit becomes fully ripe, which process takes about a week after picking.

7. AVOCADO PEAR (*Persea americana* syn. *P. gratissima*)

The avocado, also called by some as butter fruit or alligator pear is grown at present only in a few orchards at Bangalore, Shevroys, Nandi Hills, Courtallam, Lower Palnis and at the Kallar and Burliar Fruit Stations in the lower foot of the Nilgiris That it can grow on the plains also, though not as well, is clear from the performance of a tree of over 12 years of age at the College Orchards in Coimbatore. In the United States of America, the avocado is reputed as a very nourishing food of high dietetic value, with exceptionally high fat and protein content and capable of yielding larger quantities of food in terms of calories per acre than any other cultivated crop. The fruit is used as a dessert and also in the form of salads, in creams and for several culinary purposes.

The tree growth in South India is not as vigorous as it is reported to be in the United States of America and Mexico. Its climatic and soil requirements seem to generally conform to that of the mangosteen, loose jacket orange and litchi in South India, although it is seen to perform not as well as the above fruits in the region. With the varied conditions prevailing in South India it should be possible to find sites where the avocado will thrive better to be comparable to that in America, but this is a work that remains yet to be done. In view of the varied virtues of this fruit, large-scale introductions of varieties and their trials in many centres in South India seem most desirable.

VARIETIES :—The general view is that all the superior cultivated varieties of avocado, of both the West Indian and Gautemalan races, come under one species, while *P. drymifolia* includes the small-fruited varieties from Mexico, which also possess a distinct odour when the young leaves are crushed and a thinner fruit rind. Only two varieties of *P. americana* have so far been introduced to South India. One of these bears round and the other long fruits. The latter is pyriformed with a long neck and is slightly curved on the one side. It weighs on the average 14 oz. each. From the recorded descriptions, the above varieties do not seem to resemble any of the standard varieties of United States of America, and may have to be taken to be chance seedlings. The edible flesh of both is buttery, cream-coloured and of a delicate flavour, which is relished when eaten with or without salt or spice or sugar.

PROPAGATION :—The avocado can be raised from seed, and some have reported that the seed progeny of certain varieties are fairly uniform. It is however safer to adopt vegetative propagation, using the seedlings as rootstocks, if necessary. Trials at Kallar and Burliar show that layering gives about 75 per cent. success with this fruit when performed in January. Inarching on seedling rootstocks has also given a fairly high "take" of 50 per cent when the operation is done in September. Budding has been reported as very successful elsewhere, but has not yet given promising indications in the preliminary trials conducted in South India.

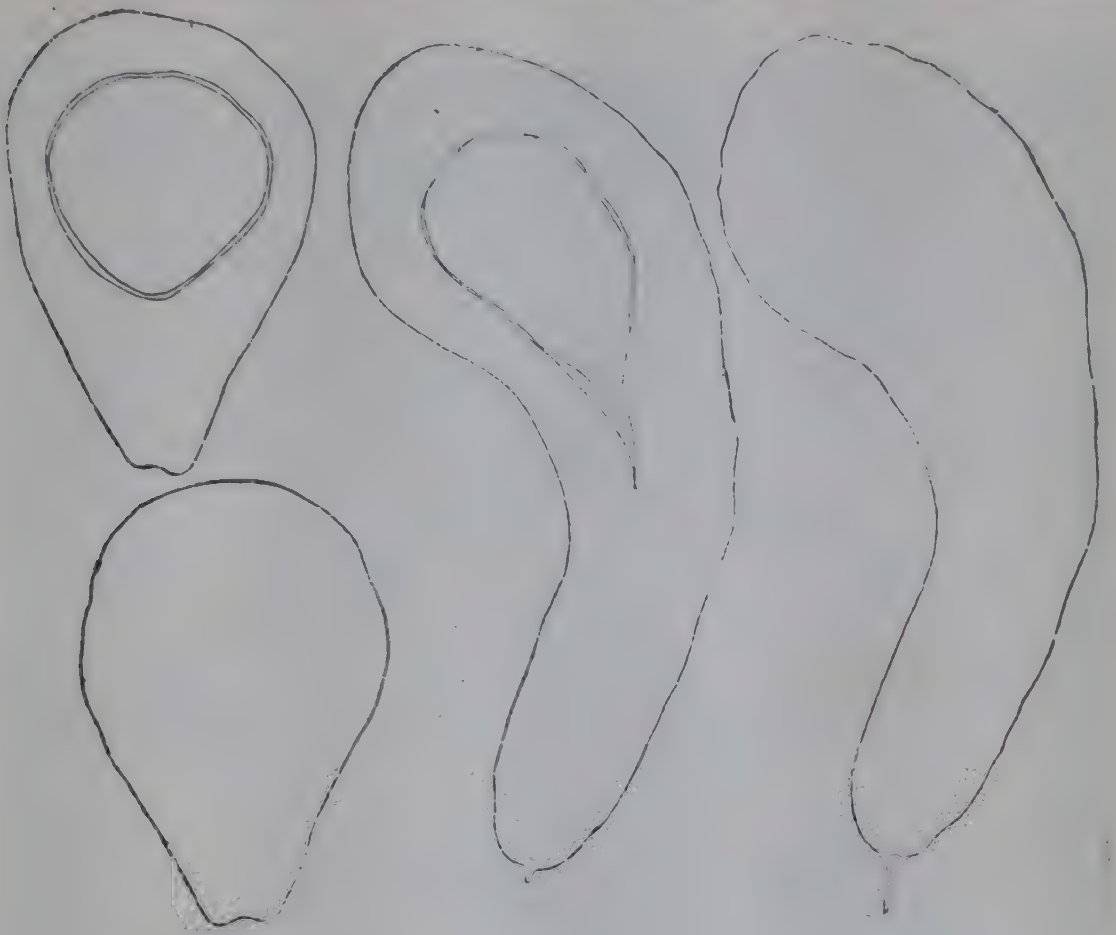

Fig. 101. Avocado pears—Long and Round—whole and in section.

PLANTING :—The trees under Kallar and Burliar conditions do not seem to require a spacing of over 20 feet. The orchard practices adopted for the fruit in these two fruit stations are not different from those followed in the case of mangosteen.

CROPPING :—The trees flower in March-April at Kallar and Burliar, and occasionally produce a second blossom in November-December. The fruits ripen in August-September and May-June respectively. The long fruited type matures usually a fortnight earlier than the round fruited type.

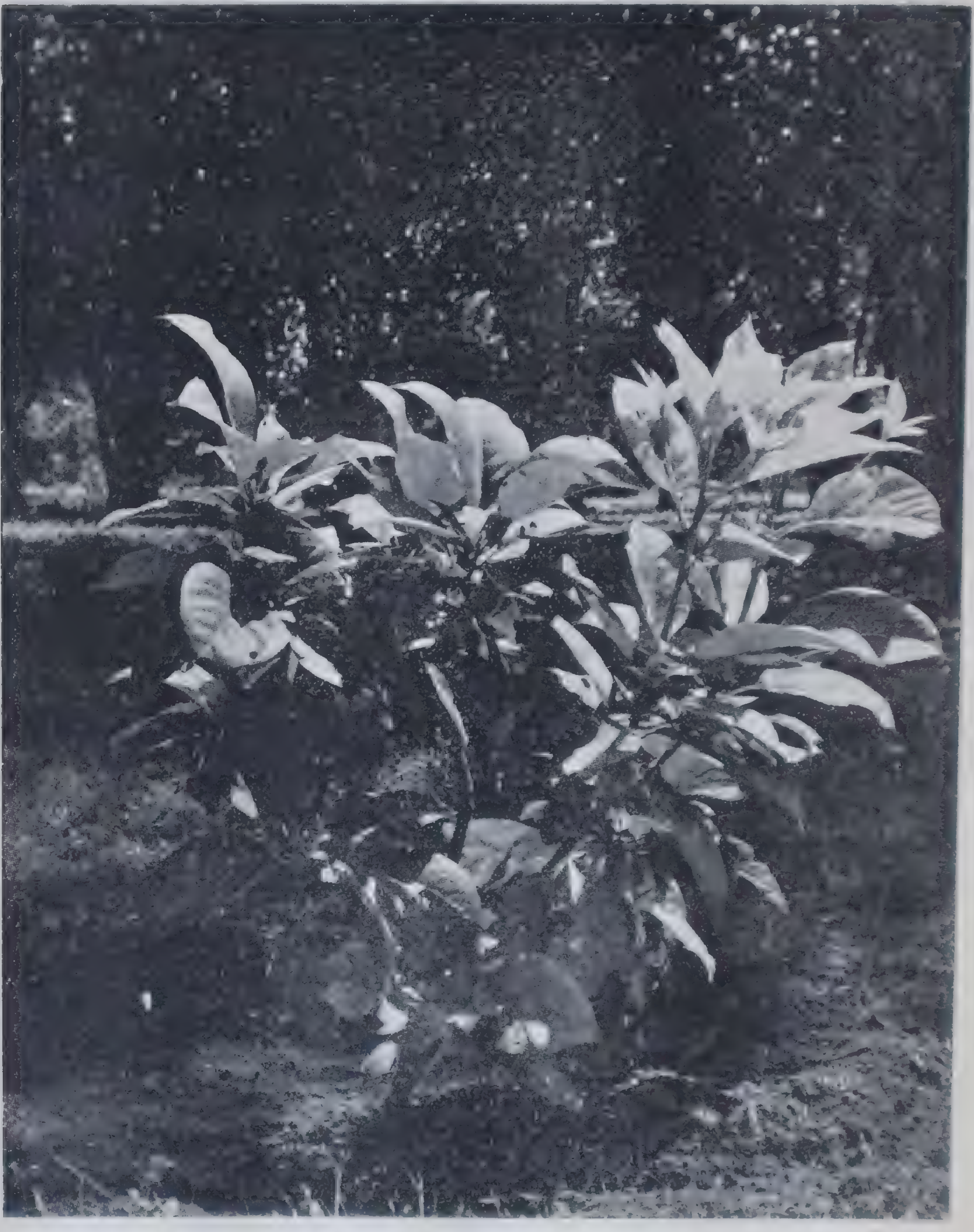

Fig. 102. An avocado layer

Work done elsewhere shows that for securing good fruit crops, the avocado plantations should be so established as to be adequately provided with suitable pollinators. Blossom biological studies with the varieties in South India have been recently commenced so as to determine the most compatible pollenising variety for either of the two varieties now under cultivation.

The avocado fruits do not soften on the tree. A slight change of rind colour to dull yellow in the round fruits and to a darker hue in long fruits is a fairly good indication of the maturity for harvesting. In California the State maturity standard is fixed at eight per cent. fat or oil content for harvest.

The fruits may be picked with the aid of a clipper to cut off the fruit stalk, which has to be later re-clipped to a "button."

The individual tree yield in South India rarely exceeds 35 lbs. of fruit per year, which is very low compared with the very high yields reported from America. In a seedling avocado grove at Hessarghatta in Mysore State at an elevation of 2,800 feet, the maximum tree yield has rarely exceeded 50 fruits.

CHAPTER VII

FRUITS COMMON TO THE PLAINS AND HUMID ZONES

Introduction :—Adopting the method of classification of fruits on the basis of their actual performance and commercial importance in South India, those that are considered suitable for being dealt with under this chapter may be papaya, sapota, carambola, bilimbi, rose and star apples, star and Indian gooseberry, annonaceous fruits other than the cherimoyer, jack and breadfruit, and the pineapple. The citrus fruits, bananas and mangoes are excluded, as they have been assigned separate chapters.

1. PAPAYA (*Carica papaya*)

A crop capable of yielding over 10,000 lbs. of food per acre in a year, equivalent to roughly twice as much food energy as that of a cereal like wheat or one-and-a-half times as much as that of a heavy-yielding vegetable like the potato, deserves a prominent place in the country's rural economy. Papaya answers the above requirements, besides being easy and profitable to grow under a diversity of conditions and a very economical and important source of certain valuable vitamins and minerals. Though largely used for dessert, and prized as such for its sweet and agreeable taste no less than for its valuable digestive properties and the high vitamin A and C contents, the fruit can also be processed in many ways for preparing a variety of products in the form of confectionery, jams, conserves, beverages and vegetable dishes. For softening tough meat, either by cooking with unripe fruit or by wrapping in crushed leaves, papaya has long been reputed. Papain is a valuable enzyme prepared from the juice of the fruit or the plant, the pharmaceutical application of which is well-known. During the cholera epidemic in 1943-44 in South India, papain was used as a valuable cholera bacteriophage by the King Institute, Guindy.

Production :—The area under papaya fluctuates from year to year, and no accurate statistics are maintained of this changing production. It is, however, curious that a considerable section of the people in Tamilnad have a prejudice against this delicious and very healthful fruit, on the wrong presumption that its consumption causes digestive disturbances. While the immature papaya fruit should certainly be deemed unfit for consumption the ripe fruit when consumed in moderate quantities will aid health and digestion instead of causing any ailment. In urban areas, particularly in Bangalore and Madras as well as in the Circars good papaya fruits are in popular demand, though the demand as well as the production are not sufficiently large as in the neighbouring province of Bombay and in North India. The present acreage under the fruit is believed to be less than 1,000 in South India; and there is no reason why this should not be increased to 10 times that figure or more.

CLIMATE AND SOIL :—Successful papaya production is possible in all parts of South India, excepting on elevations exceeding about 5,000 feet from the mean sea level and on sites subject to frosts or frequent cyclonic weather. The performance is good both in the arid but irrigated orchards of the Ceded Districts, in the delta areas of the Circars, in the lateritic soils of the West Coast or in the humid situations on our hill slopes under practically rain-fed conditions. Though adapted to a wide range of soils, the best performance is seen on rich loams of uniform texture up to about six feet in depth, to which the roots forage normally in search of food and moisture. Perfect soil drainage is a very important requisite. In ill-drained soils or when the sites become water-logged for a few days, the papaya is liable to serious damage or even sudden death, either by over saturation of the root system or by the devastation of collar rot disease which is fostered by wet soil conditions in seasons of high atmospheric temperature.

VARIETIES :—A very large number of so-called papaya varieties is found in cultivation. As a matter of fact none of these is a real variety, since it cannot be relied upon to reproduce the parental characters in all the progenies. Nine so-called varieties were tested at the College Orchards, Coimbatore and all were found to produce a varying proportion of seedlings quite dissimilar to the parents. However, due to continuous selection, several seedling races are found to produce fairly large proportions of progenies true to the parents from seed; and of these the Washington of Bombay side and Honey Dew enjoy some popularity in South India. There are also several others which have acquired local reputation and are the basis of continuous selection by individual growers over a long period of years.

Imported races and strains from Hawaii, South Africa and Ceylon have almost everywhere failed to reach the standard of the local ones and are therefore gradually fading out of South Indian commercial orchards. In the Kallar Fruit Station collections, a local selection named Burliar Long, was found to produce about 70 per cent. of female trees in the seed progeny, which commenced flowering within three months of the planting of trees in the orchard. The fruits in this variety are densely packed along the

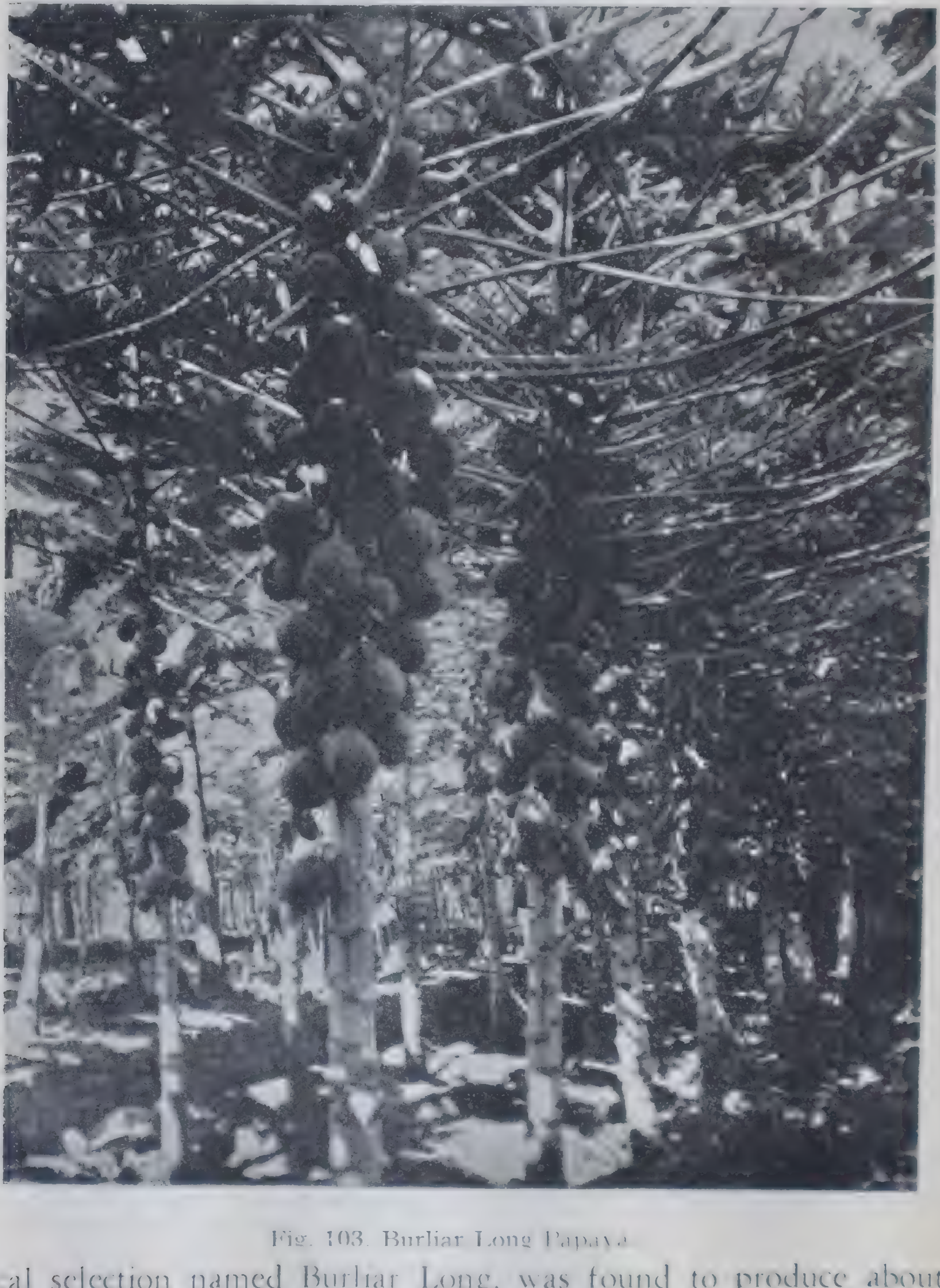

Fig. 103. Burliar Long Papaya

stem, numbering on some trees up to 103 per tree in the first year. The fruits at each node tend to be borne in pairs, and several trees produce fruits within about 18 inches from the ground level. As against this, the Honey Dew has a more slender stem, produces fruits singly at each node, and gives pistillate trees in the seed progeny only up to about 47 per cent. in bulk plots. The Washington papaya has purplish leaf stalks, which characteristic is also found in several other mixed strains. It is difficult to judge the strain suitable for any tract, since the quality of fruit and several other economic characters seem to vary greatly, partly because of the mixed inheritance and partly due to environmental influences. It will be best if each grower selects the best trees in his own region and pursues such selection work for some generations.

Sex and Breeding :—An important feature of the papaya is that the flowers are among the most complex of the cultivated fruits. According to the distribution of sex in this fruit, 13 different forms have been described. Of these, the important groups are (i) the male trees which are incapable of producing fruit until they change their sex, as some do, (ii) the female trees, which are the main fruit producers, and which are never known to alter their sex, and (iii) the various forms of perfect-flowered trees, which produce a bulk of irregular-shaped fruits and rarely yield heavy crop, and are therefore of little or no economic value so far. The common papaya being normally dioecious, bears the staminate flowers on one tree and the pistillate ones on another. This dioecious flowering habit favours cross-pollination, and it is natural therefore that the seedling strains should have a mixed inheritance, so that it is difficult to grow a standardised crop in a plantation. The worthless types that appear as individual segregates are a distinct loss ; and to overcome this, breeding work has been in progress in many lands. Hofmeyr from South Africa has suggested that, selection of seed from the best female trees if followed by controlled hand-pollinations between the brother and sister plants during about four generations, will lead to definite progress in the matter of obtaining comparatively uniform types with respect to fruit quality, keeping quality, shape and size of fruit etc. It is possible that with the continual inbreeding to the 3rd or 4th generations, there may be some loss of vigour in the in-bred strains, but it is stated that vigour can be restored by the crossing of two or more in-bred lines. These in-breeding methods are yet to be pursued on an extensive scale in South India. The results of preliminary trials with some of the in-bred strains imported from South Africa seem to make it necessary to test the claims made for the method, under South Indian conditions, since the imported in-bred South African strains have not shown any more encouraging behaviour than the local selections either in respect of uniformity of characters, or in the percentage of pistillate trees in seed progeny, or even in the matter of yield or fruit quality.

PROPAGATION :—The papaya is almost universally raised from seed. On selecting the parent tree, the seeds are extracted from ripe fruits. They are then washed in water to remove the gelatinous covering, and dried in shade. In order to secure maximum germination, the seeds are best sown as soon after extraction as possible. Roughly four to eight oz. of seed may suffice for raising the required number of trees for an acre. The seeds may be sown in raised seed beds, seed pans, pots or other containers commonly used in nurseries. Sowing in beds is regarded as superior for securing higher germination and the least damage from damping off disease. Sowing may be done in any part of the year except during the hottest, rainiest or coldest periods. In most parts of the country, June to November provides the optimum sowing season. The seeds are dibbled at a depth of half-an-inch with a spacing of one half to one inch in the row and about nine inches between the rows. They are then covered with soil first, followed by a thin layer of sand. Watering is done immediately after the sowing, preferably with a can fitted with a fine " rose. " Watering should continue regularly and on every day thereafter except during rains, but only during the cool morning or evening hours. An artificial shade with thatch may be used to protect the young seedlings from heavy rains and severe sun.

TRANSPLANTATION :—Germination occurs in about three weeks, a few days after which the seedlings should be thinned out to a spacing of two to three inches in the row. The surplus seedlings can be transplanted into a separate bed if lifted out with care along with a ball of earth around their roots. Some growers transplant all the seedlings a month after sowing to new beds, while most are content to transplant the seedlings to the final sites when they are six to nine inches high in about 75 days after sowing. In the former case the final setting out in the field is usually done when the transplanted seedlings in the new beds attain a height of about twelve inches. Whatever be the method adopted, it is necessary to clip off most of the leaves three or four days before every lifting operation. At the time of lifting also it is essential that every plant is taken out with a ball of earth and is put in its new site with the minimum delay after lifting.

It is also possible to raise a plantation by sowing the seeds direct in the final orchard sites, but this is a practice which is reported to result in a low crop yield on one hand, and in an increased cost of orchard maintenance on the other.

VEGETATIVE PROPAGATION :—Observations show that in seedling plantations as many as 60 per cent of the trees may turn out to be the unproductive males. Elaborate studies have failed to give any reliable means of detecting the sex in papayas before the trees flower. These facts have led research workers to try vegetative propagation methods. Rooting papaya cuttings, though found successful to a degree, is not feasible on a commercial scale, because of the difficulty to secure the required number of cuttings for large scale plantings. Grafting by approach method on seedling papaya rootstock as well as on mountain papaya (*Carica candamarcensis*) of 1 to 2.5 cm. stem-thickness has been recently tried with cent per cent. success at Burliar Fruit Station in Madras. Side and cleft grafting on about 30-day-old papaya seedling rootstocks has also been attempted with equally high success by the author at Sabour in Bihar. In both these cases, the limiting factor is the unavailability of an adequate number of scion shoots. Further, experience of growers in Florida seems to show that grafted trees degenerate progressively, so that grafted plantations of the fruit have now become things of the past in that country.

The grafts on hill or mountain papaya planted at Kallar in December 1945 have all turned out to be pistillates. This fact offers a promising field for top-working the surplus unproductive males and other inferior trees in the orchard with scions from selected pistillate trees.

PLANTING AND CULTURE :—The fact that the male trees are unproductive should not mislead one to the inference that they should all be eliminated from the plantations. Although papayas are known to fruit even when the pollen-bearing male or hermaphrodite trees are not close by, the fruits that set under such conditions are relatively few in number and are reduced in size, besides being seedless. For normal development of fruit and for securing high yields it is necessary to retain about one male tree to every ten to twenty female trees in the plantation and to spread out the male trees in all parts of the orchard. The most effective and the only feasible way now open to ensure the required proportion of male and female trees is to plant in the field three to four seedlings in each pit, roughly one foot apart from each other. As soon as the plants flower, only one tree is retained per pit and the rest are grubbed out, keeping in view the required proportion between male and female trees in the plantation.

Being easy of culture, the papaya requires but little skilled attention in the orchard. The usual operations preliminary to planting in the form of several ploughings and harrowings, marking out the sites for the plants and digging of pits about two feet cube, are common to papaya as to several other fruits. A strong windbreak may be raised along with or well ahead of the planting. Cool or cloudy days should be chosen for the planting, and even then the actual lifting out and setting in the field may as far as possible be attended to in the evenings. Eight to ten feet on the square is the normal spacing given to the trees. Watering the trees is done in basins immediately after planting, and regularly thereafter whenever the first six-inch layer of soil is found dry by rough tests. Excess of moisture at the roots and prolonged contact of it with the stem are to be avoided. The latter is easy if the basin is made to slope away from the trunk gently. When the papaya trees tend to be tall it may be advisable to keep the tree stature under certain limits to enable easy harvests to be made or to facilitate tapping of fruits for papain by workers standing on the ground. Heading back of the stem is the obvious and easy means to confine the bearing regions of the tree at the required heights. When the stems are headed back, an earthen pot is usually placed over the cut stem with its mouth pointing downward. This prevents the rain water entering inside the stem cavities and thus favouring the rotting of spongy tissues.

For a gross feeder like the papaya liberal applications of manure are necessary. Among the several suggestions made, that by Cheema and Dani seems appropriate to most Indian plantations. It consists of the application of 20 lbs. of well-rotted farm yard manure to the tree at about the time of planting, followed by 80 to 100 lbs. of the same after four to five months, with a third application of the same quantity in the succeeding year before the rains set in. Bone meal or bone ash has also been recommended to be applied after the rains in about September. Excellent crops of papaya have also been raised in several places entirely on the sewage effluent.

Inter-cropping of the papaya orchard with vegetable can be done during the first few months of planting. This is a practice that has much to commend during the early life of the orchards.

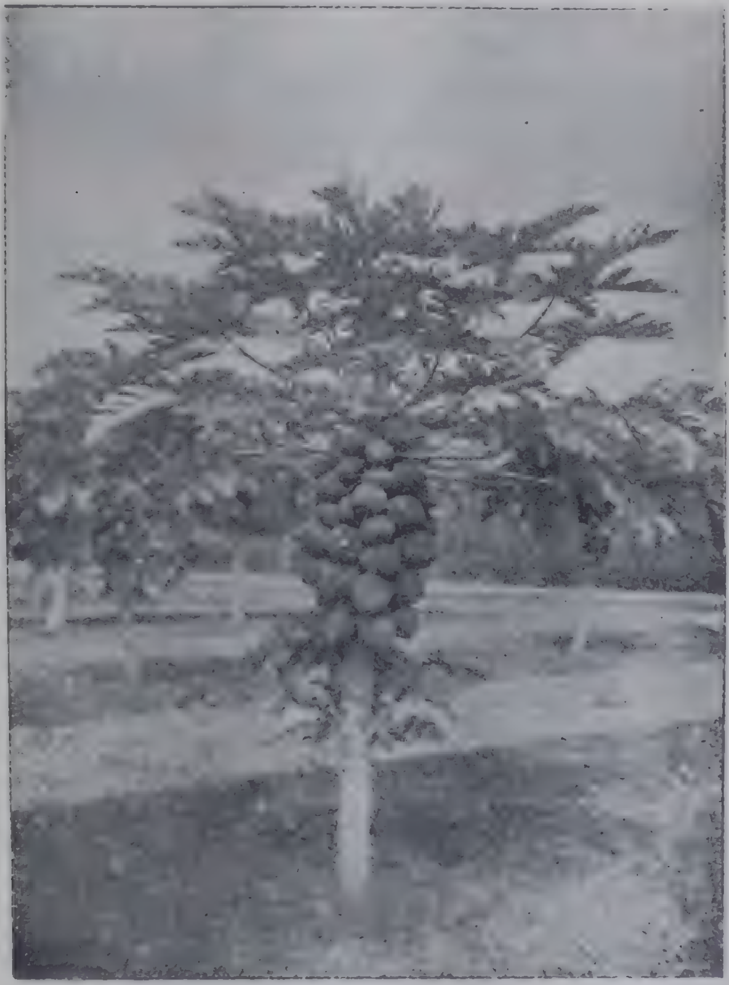

Fig. 104. Papaya in fruit.

A shallow rooted plant like the papaya with its feeding roots appearing below four to six inches of the soil surface, cannot naturally relish deep soil culture. To keep down weeds, frequent hoeing of the basins with hand tools or shallow inter-cultivation with implements like the Planet Junior Hand Hoes are suggested.

Papaya can also be grown as a "filler" or catch crop in tree fruit plantations or amidst cocoanut groves. Since the papaya trees rarely give profitable yields after three to four years, and occupy little orchard space, they can be raised once in the pre-bearing stage of the tree fruits, with profit.

Cropping :—In about six months of planting, seedling papaya trees begin to flower normally, and in another six months the fruits will be ready for harvest. Except during the colder seasons, the trees continue to flower and fruit almost all the time. Periodical inspection of the trees to thin out fruits, which cause over-crowding on the stem, is necessary. When a change of rind colour to yellow is observed on the fruit, it may be deemed ready for harvest. The fruit should be handled with care at all stages. A soft wood wool padding to the basket or box in which the fruits are to be kept or transported and a single layer packing of uniform sized fruits are recommended to enhance the sale value and reduce damage.

The yield of fruits has been variously estimated in different parts of the country and is believed to range in normal plantations from 30 to 150 fruits per tree, each weighing from one to over 16 lbs. The acreage yield may work out from 30,000 to even over 60,000 lbs. At Hessarghatta the yield from an acre has been reported to be 13,000 fruits weighing about 43,500 lbs. The pink or purple stalked Washington was found to yield the maximum, while the so-called Honey Dew gave a yield of only 15,221 lbs. for the acre. The individual fruit weights in the above were found to be 4.1 lbs. and 3.3 lbs. respectively. All these figures relate to the first three years of the plantation. At the end of the third year, the papaya will have passed out of its profitable bearing age, and the trees may therefore be grubbed out.

From an analysis of performances of the papaya at College Orchards, Coimbatore, it is found that trees begin to fruit there from seven to 16 months, and the yield varies from 27 lbs. to 167 lbs. or 12 to 110 fruits within the first 23 months, with an average of 31 fruits or 62.8 lbs. per tree, working out to an acreage yield of 42,840 lbs., if all trees are females.

Papain :—Papain, as already stated, is an active enzyme and is present in the latex or milky juice of the papaya plant and its immature fruits. It has become an important article of international commerce, since it has properties similar to pepsin and is being used by medical men in a variety of ways. Trials on the collection of papain as carried out at Kodur have given certain encouraging results. The following is a brief idea of the methods used at Kodur for preparing crude papain.

Papaya milk or juice is secured by tapping the green, unripe but well-developed fruits of female trees. When the milk is properly dried, it is practically white in colour, while the poorly dried article may be brown or black. To secure a good flow of milk, the fruits are scarred with an instrument such as a steel knife or even a wooden tool with thin and sharp edge. The tapping may be done every morning and evening. A number of scars are made on the skin, but not so deep as to wound the flesh inside. The scars may be few and placed far apart in the beginning, but may be gradually increased to cover almost the entire skin. The optimum interval between any two successive tappings of a given fruit is believed to be four to five days. Before the scars are made, an empty cocoanut shell or a small earthen cup has to be loosely suspended close to the fruit, in a position most suited for collecting all the milk flowing out of the scars. The milk in the receptacle as well from the top and sides of the scars, where it gets deposited in a semi-solid mass, should be collected frequently and at least twice a day, and should be dried immediately and as quickly as possible. A small drier can be prepared locally for this purpose. It should be such as can be heated by artificial means by burning of wood or charcoal. A plan for such a drier has been suggested for dehydrating bananas also. The coagulated milk is broken up to facilitate quick drying and is spread thinly on wooden trays, over which cotton cloth is tacked sometimes. In the last case the cloth has to be frequently removed when it gets too hard by drying, and is soaked and dried in sun before using again. The cloth should not also be saturated, as this will hinder drying. If the drying is to be done in a place or season when the atmospheric humidity is high, it has been suggested that the excessive atmospheric dampness can be removed by means of a fan, the air passing through calcium chloride crystals, which are placed about three inch thick in a frame. As the moist air passes through these crystals the surplus dampness is removed. As the crystals become saturated in course of time, they are removed from the frame and dried out and used over again. At Kodur no necessity was felt to remove the excess dampness, but the product was not as white as the best quality product is required to be. An experienced chemist and planter from Canada has reported to the author that while the product becomes dead white in colour in most places, that produced from a papaya grove in one of his plantations located near a volcano in the West Indies gets a rose colour even when dried as above. The dried milk has to be placed in "air tight" containers of tin or glass, so that atmospheric dampness be excluded from the contents. For properly dried product on the above stated lines, a firm in Canada has offered to pay from $ 1.30 to $ 1.40 in U.S. funds per pound.

It is suggested that the seeds from tapped fruits should not be used for raising fresh plantations, as such seeds are believed to produce weak trees. The tapped fruits, though apparently less attractive, are nevertheless fit for consumption in the same way as untapped fruits. Mature and picked fruits are of little or no use as sources of papain.

No definite idea of the papain yield is possible, as the trials so far done were not sufficiently comprehensive nor systematic. In the preliminary tappings, however, an average of 3.75 gms. of dried milk per fruit was obtained at Kodur.

PESTS AND DISEASES :—Work on papaya pests and diseases has been meagre, but fortunately the fruit is also almost free from severe pests. Among the diseases, the collar rot is the most serious. This is believed to be similar to the foot rot of the northern parts of Bombay presidency, said to be caused by *Pythium aphanidermatum.* The causative fungus is soil borne, in consequence of which control is difficult. Better drainage of the soil helps to check the spread of the disease. In severe cases it will be best to grub out the affected trees and not to have fresh papaya plantations close by. Another disease causing leaf spot and fruit rot has also been reported. This is caused by *Gleosporium* sp. and is controlled by spraying with Bordeaux mixture and by prompt removal and destruction of diseased plants. In periods of heavy rains, the trees standing close to a tank or river in spate or in low-lying sites often get submerged, in which event the trees usually collapse in a couple of days. This is partly due to the suffocation of the roots and partly due to the rotting of the stem and the roots. Perfect drainage is indicated therefore to be of great importance to the papaya all through its life.

PLATE X. A SAPOTA GROVE

List of References.

1. Cheema, G. S. and Dani, P. G.—Papaya Cultivation in Bombay Presidency. Bull. 16, Dept. Agri., Bombay, 1930.
2. Hofmeyr, J. A. M. and le Roux, J.C.– Farming in South Africa; Aug., 1939.
3. Naik, K. C.—Village Orchards—Papaya—Developing Village India—Special Number, "Indian Farming", 1946, pp. 215-218.
4. ,, Fruit Personalities—Papaya—*Mezhichelvam* (In Tamil), Madras, April, 1945.

2. **SAPOTA** (*Achras sapota*—Syn. *Sapota achras, Sapota zapotilla*)

This fruit is known by several names in different parts of the world such as sapodilla, chiku, dilly, chico, naseberry, and sapodilla-plum. It is not to be confused with the sapote or mammey sapota, which belong to a different species, *Achras zapota* syn. *Lucuma mammosa, Calocarpum mammosum, Achradelpha mammosa*). The sapote also bears edible fruits of a russet brown colour and scurfy surface, but its leaves are quite distinct, being almost similar to the loquat in outline and are clustered at the terminal parts of the limbs, while its flowers are borne in the axils of fallen leaves on fairly stout branches. The sapote is not under cultivation in South India, whereas the sapota is among the most popular fruits, and is grown mainly for dessert purposes. Sapota jam has also been prepared, but it does not seem to offer much possibilities. In the United States of America and Mexico, the milky latex of the bark of sapota is used to prepare chicle, a basic substance in the manufacture of chewing gum.

The area under sapota in South India is not definitely known. In 1942-43, it was estimated by the Madras Marketing Section that about 220 acres were under this fruit in that province, but this figure was deemed incomplete. Taking South India as a whole, the area under sapota may exceed 500 acres.

CLIMATE AND SOIL :—The sapota is one of the most adaptable of the tropical fruits and has been found to thrive under a diversity of soil and climatic conditions up to an altitude of about 4,000 feet from the mean sea level. There are indications, however, that the trees crop better at the elevations lower than about 1,500 feet than above it. In the former region, enormous yields are secured both under arid and humid conditions, provided the trees are supplied with sufficient moisture at the roots during seasons of stress as the summer. In respect of soil, it seems as if the fruit prefers a sandy loam, although good harvests and robust tree growth have been observed in well-kept plantations on soils of such varying texture as the lateritic gravelly soils of the West Coast, the sandy strips of the littoral area and the clayey black cotton soils of parts of the Ceded districts.

VARIETIES :—Over a dozen varieties are under cultivation in South India. These differ in shape, fruit size and eating qualities. Cricket Ball sapota, so named because of its large fruits resembling the cricket ball in size, has crisp and granular flesh of moderate sweetness, and is a favourite among most of those who have sampled its mature fruits. This variety, however, appears to produce tastier fruits at elevations below about 1,000 feet and under relatively arid atmospheric conditions. It yields relatively less crop than the smaller fruited varieties. Dwarapudi of the Circars is next in size of fruit and almost similar in taste. Bangalora and Vavivalasa varieties are also popular in the Circars and produce oval fruits, but are relatively unthrifty. Kirtabarti is another variety popular in the Circars, producing fruits of peento form and of medium size, while Jonnavalasa is specially popular near Vizianagaram and bears roundish fruits of small to medium size. The Pot sapota is grown in a few orchards in the Circars and is characterised by relatively dwarf tree size and precocious nature such that it is believed to be possible to raise this variety even in pots for about 10 years. Calcutta and Gouranga sapotas are other small-sized, oval fruited varieties, which are also prolific, while the Pala is yet another popular variety which produces small, roundish to oval fruits of good flavour. The distinction between varieties is recognised mainly in Telugu parts, while elsewhere the more important commercial varieties are restricted to the small-fruited forms, which are generally classed under the groups of round or oval sapotas.

PROPAGATION :—Seed propagation is not adopted in commercial plantings, as this does not ensure true-to-type plants. Layering, gootee and inarching are therefore common. Layering is popular, since it is easy and the least expensive. Of late, inarching is gaining much popularity, the rootstocks in use being seedlings of sapota, of *Bassia longifolia*, *Bassia latifolia* and several species of *Mimusops*, of which *M. hexandra* is the most fancied. Preliminary trials at Kodur, Taliparamba and Kallar have shown that side-grafting of sapota on all the above rootstocks is possible. At Taliparamba, side-grafting in September 1946 gave a successful "take" of 33 per cent and the grafts attained a height of about 2 feet in about 10 months. Sapota cuttings also remained alive at Taliparamba for about 10 months, though failed to strike root. For inarching, August and September proved to be the best months giving about 100 per cent "take" on *Mimusops hexandra.* The *Bassia* species when used as rootstocks for the sapota are commonly believed to provide less satisfactory orchard trees than *M. hexandra* or sapota seedlings, some reporting that the sapota exhibits incompatible unions with *Bassias.* The rootstock material of *M. hexandra* can be raised both by seed and cuttings, the latter having been found possible if the cuttings are prepared and inserted during a rainy season. Definite information on the most economic stionic combination for sapota as well as the optimum propagation technique are yet to be gathered for the varied conditions in South India.

Top-working of inferior sapota trees by side-grafting has been found possible at Taliparamba, adopting the slotted side-grafting method as that used for mangoes in the West Coast. In a trial carried out in 1945, two trees of about 20 years of age were headed back to a height of about 3½ feet from the ground, and two more had their main limbs lopped off in October. On the trees of both the batches, scion shoots from superior trees were inserted; and in either case a 50 per cent "take" was registered.

PLANTING :—Depending upon the variety and site, the sapota trees develop into varying sizes, so that a uniform spacing is not feasible to be adopted in all parts of the region. Generally speaking, a spacing of 20 feet from tree to tree may be adequate in infertile soils and under rain-fed conditions, while 30 to 35 feet may be necessary elsewhere. Being a hardy tree, little attention is bestowed on sapota culture and still less is known of its varied requirements. Like all other fruits, the trees are planted from June to January. No pruning is given to the tree at any stage of its life, excepting for the removal of dead shoots once in a way.

CROPPING :—Layers and grafts commence to fruit in about four years, although some have been known to produce a few fruits even in the second year of planting, while the seedling trees take about six years to fruit. Crops are usually heavy and mature in two main seasons—once in February to June and again in September to October. It is however possible to have some fruits from the tree all the year round, which feature is exploited sometimes by some nurserymen to sell plants in the name of Baramasis i.e., all the year-round cropping varieties. One such Baramasi planted at the Taliparamba orchards proved to be synonymous with a standard variety already known by another name. On the same station, observations made in 1946-47 have shown that the sapota trees flush and flower at intervals of about two months, and fruits were available for harvest in all months of the year except September, with peak seasons in November-December, March, April, May and June.

There is some difficulty in determining the exact stage of maturity for picking sapota fruits. The safe procedure is to delay the harvest till a few fruits soften on the trees, but this necessitates frequent inspection of the crop. Trials at Kodur have shown that with many varieties, the colour immediately below the dark brown rind changes into a lighter hue when reaching full maturity. In some, the rind also gets a lighter splash at this stage. Experienced growers can therefore judge the stage of maturity by noticing these changes on the rind colour as well as by scratching the skin of a few fruits to observe the colour changes immediately below the rind.

An average yield of over 700 fruits per tree per year can be expected in about the eighth year of planting, while from the 10th year the yield may exceed 1,000 even reaching up to 2,000 in some trees and varieties.

PESTS AND DISEASES :—Sapota is remarkably free from any pests or diseases of importance in South India.

RELATED FRUITS :—Among the edible fruit bearing species of the same family as the sapota, is the *Sideroxylon tementosum*, which is a thorny tree found in the Western Ghauts and in the Circars. Fruits of these are used in culinary preparations and for preparing pickles. The mahua tree (*Bassia latifolia*) is another species of the same family and of considerable economic value. It is popular as an avenue tree in South India; and both its fruits and succulent corollas of flowers are eaten raw or cooked, while the oil and oil cakes prepared out of it are also popularly used in households and as manures respectively.

Literature

1. Naik, K. C.—Fruit Personalities—Sapota. *Mezhichelvam* (In Tamil), Madras, March, 1945.

3. CARAMBOLA (*Averrhoa carambola*)

This is grown in home gardens largely for using the fruits in culinary preparations, in which it provides a suitable substitute for tamarind. The juice of the fruit is used for drinks; and jam, jelly, pickles and preserves are also made out of the fruits. The pulp of immature fruits is said to be useful in cleaning

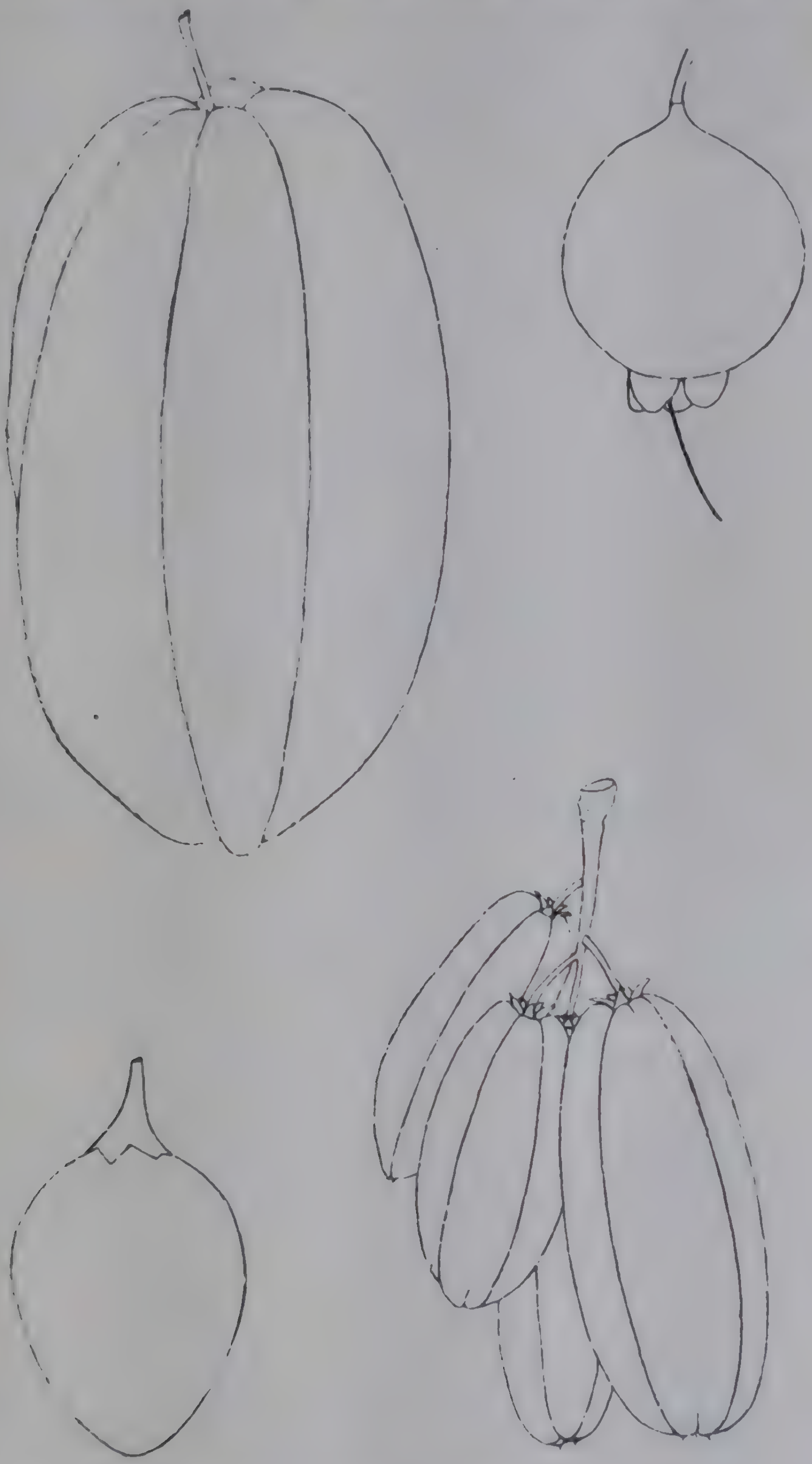

Fig. 105. Fruits of carambola, rose apple, tree tomato and bilimbi.

brass vessels and in removing stains from linen. The fruit is oval-elliptic, three to five inches long and three to five ribbed, giving in cross-section a star shaped figure. It is also called as kamrakh in North India.

The carambola thrives in warm, moist situations as in the West Coast, and on the lower slopes of hills up to about 4,000 feet elevation, as well as in sheltered compounds all over the plains.

Two types, one slightly sweet-fruited and the other producing acidic fruits which are watery and astringent when immature, are found. The former is relished by some persons as fresh fruit, even though it cannot be classed as a superior table fruit.

The common method of propagation is from seed. Work at Kallar has proved that both layering and inarching are easy and should be preferred. The former gave over 60 per cent. success when the shoots were layered in September, 100 per cent success when done in January, while inarching on seedlings of carambola of 1.0 to 1.5 cm. thickness in June and January gave 80 and 100 per cent " take " respectively. Seedlings are likely to produce variable progeny, which fruit only in about four years of planting, whereas the grafts at Kallar commenced fruiting in 10 months from the date of planting.

The plants are usually set out in the orchard with a spacing of 20 feet. The tree assumes a symmetrical shape and is ornamental. Neither any pruning nor any special care on its upkeep seems necessary under South Indian conditions.

The trees flower and ripen fruits in large quantities all through the year, although the peak harvests are from January to February and from September to October. The individual tree yields range from 100 to 250 lbs. in a year.

4. **BILIMBI** (*Averrhoa bilimbi*)

This is similar to carambola, but produces more acidic or sour fruits, suitable for pickling and preserving and also has larger leaves with five to seventeen pairs of leaflets in place of two to five in carambola. The fruit is more cylindrical or obscurely 5-angled and is two to four inches in length. The propagation and culture are not dissimilar to that of carambola.

5. ROSE APPLE (*Eugenia jambos*)

An ornamental tree, producing pretty, round or nearly spherical fruits, each one to two inches long, greenish white in colour, delicately perfumed with the odour of rose water and with a juicy flesh of sweetish taste, this is a popular home garden tree both in the arid and humid tracts of South India up to an altitude of about 4,000 feet. The fruit is propagated by seed, which is polyembryonic. Of the 30 seeds sown in July 1945 at Taliparamba and 60 sown in June 1946, one in the former and 3 in the latter produced 3 seedlings per seed, and 8 in the former and 16 in the latter produced two seedlings each per seed, giving a mean number of seedlings per seed of 1.33 and 1.36 respectively. Layering is possible, but may perhaps be unnecessary. The trees are found to yield each about 5 lbs. of fruit per annum, the blossoms occurring in about January and the fruits maturing in March-April. In the Circars the fruits mature slightly later, from April to May. The fruits can be easily candied.

6. OTHER EUGENIAS

1. *Eugenia javanica* is similar to rose apple and is also found as stray trees in the home compounds in South India up to an elevation of about 4,000 feet. This produces larger trees with larger leaves than the *E. jambos*, with fruits, rather bell-shaped, two to three inches long, and white to crimson in colour. The flesh is also white and juicy with an agreeable flavour, but with no perfume. Seed propagation is the rule, but layering has been found easy at Kodur and grafting with rose apple as a stock at Kallar. The trees are very prolific, as many as 700 fruits having been harvested from a five-year old tree at Kodur. The fruits are in season from March to May.

2. *Eugenia jambolana* (Syn. *Syzygium jambolanum*) or the jaman is a large tree found in forest areas in South India and is also sometimes planted as shade trees on road sides. It produces an abundance of purple coloured oval fruits with large seeds. The flesh is edible, though not of any distinguished flavour. There are two types, one producing larger-sized fruits than the other. The propagation is by seed. The fruit is also sometimes known as the black or purple plum and appears in markets in June to August.

3. *Eugenia uniflora*:—This has been dealt with under Hill Fruits.

4. *Eugenia zeylanica* (Syn. *Syzygium zeylanicum*):—This is a small tree, handsome in appearance, and found in the Western Ghats. It yields also edible fruits of whitish colour.

5. *Eugenia malaccensis* is simlar to *E. javanica* but is more pronouncedly bell-shaped. It exists only as stray trees in South India.

7. STAR APPLE (*Chrysophyllum cainito*)

The star apple tree is also ornamental and of huge size with leaves covered beneath with a lustrous pubescence. It is grown in the same places as the rose apple, and produces round or oblate fruits, each two to four inches in diameter, light green or dull purple in colour and with a glossy rind. The flesh is sweet and granular. It is also propagated by seed. At Kallar the full grown trees yield each about 150 lbs. of fruit per year, from February to March.

Inarching of rose apple on star apple and *vice versa*, or on their own seedlings have been found easy at Kallar and Burliar fruit stations.

8. INDIAN GOOSEBERRY AND ALLIED FRUITS

1. AMLA (*Phyllanthus emblica*—syn. *Emblica officinalis*):—This is often called as Indian gooseberry or emblic myrobalan or nelli or amla. It is found in tropical forests as well as on hill slopes up to about 4,000 feet elevation and is also popular in home yards. The fruit is green and assumes a light yellow or brick-red colour when mature. Its characteristic is that if water is drunk immediately after tasting the acidic fruit, a very sweet taste is formed in the mouth, which peculiarity has made this fruit reputed in folk lore and among the people in rural parts. Reputed also as a rich source of vitamin C, the fruit acquired some importance during the last war, when dehydrated amla powder, amla tablets and amla candies were prepared for use by the Army. The amla tree is ornamental and grows well up to an altitude of about 4,000 feet both in arid and humid zones. The tree is propagated by seed, and it is believed that trees reproduce fairly true to the parents by this means. The trees mature fruits during the cold and early summer months of the year in South India—July to March, although some fruits are available even during the rest of the summer. At Kodur the trees flower twice, in July and February. Fruits from the former are ready for harvest

in January, while the February blooms fail to set any sizeable crop. On the Lower Palnis the harvesting season is mainly from September-January. The fruits make also a delicious pickle and a fine candy. A large fruited variety exists and this is specially fancied in home gardens.

2. OTHEITE GOOSEBERRY (*Phyllanthus acidus*—syn. *P. distichus and Emblica distichus*):—The other name by which this fruit is known is star gooseberry. It is grown mainly in home yards for its ornamental trees and attractive, round or peento-form fruits, which are deeply ribbed, acidic and pale green in colour. It is found in the same situations where amla is grown and is also raised by seed. It bears generally two crops in a year, once in

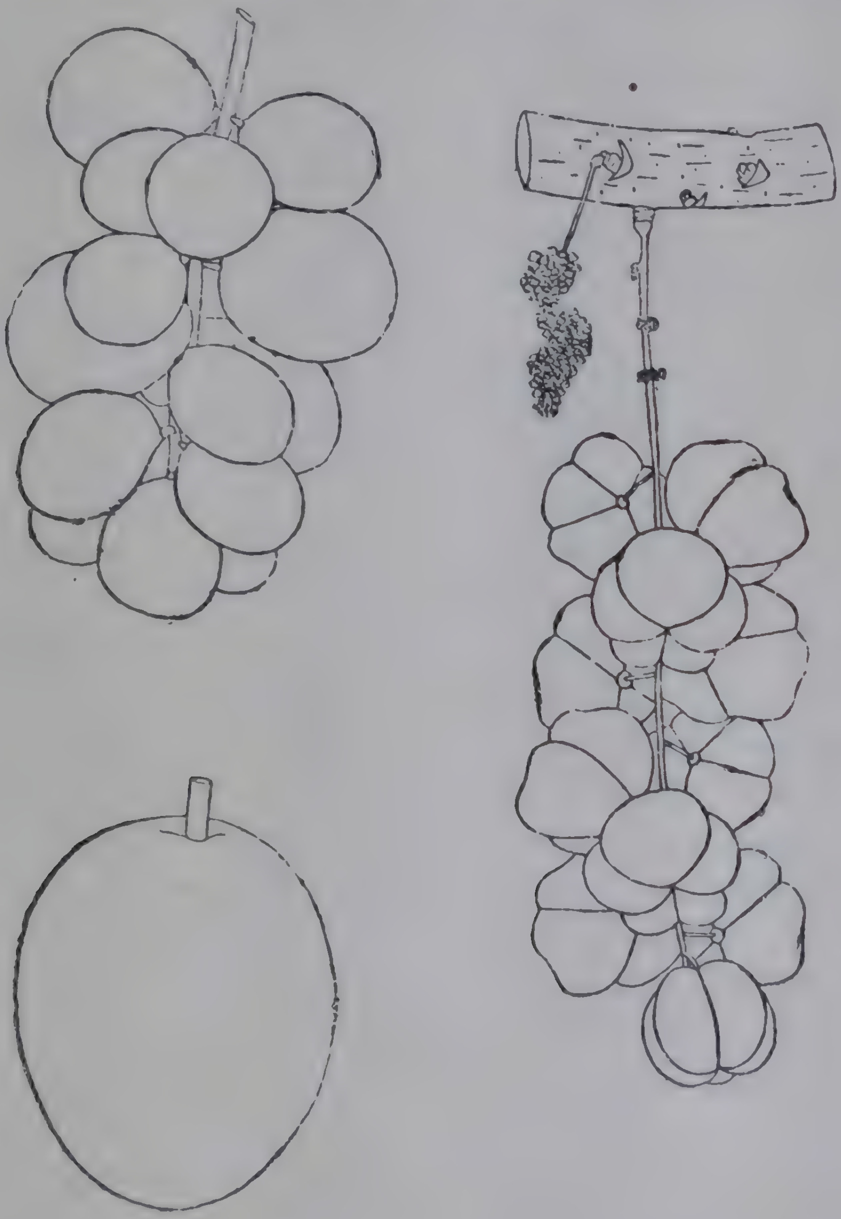

Fig. 106. Fruits of langsat, star gooseberry and passion fruit.

April-May and again at the end of the monsoon in August-September. At Kodur experience seems to show that the peak harvests are in January though a few fruits may be got all the year round. The fruit is also used for pickling, candying and for dessert purposes as the amla.

3. *Phyllanthus Fischeri* (syn. *Emblica Fischeri*) is reported to be also found in the forests and is said to produce fruits suitabl for pickling.

9. ANNONACEOUS FRUITS

1. Custard apple (*Annona squamosa*):—Also called as Seethaphal or sugar apple, this is a very popular fruit in all parts of South India and to many is the best of the annonaceous fruits, even though the cherimoyer has been declared to be superior according to the taste of Europeans. The plant delights in hot and relatively dry climate, although it can be grown up to an altitude of about 3,000 feet and also in humid areas on the hill slopes. Not being a commercially cultivated fruit on any large scale, figures of production are unavailable, but there is little doubt that the fruit is produced in enormous quantities in the forest areas such as to vie with most cultivated fruits in the quantity of annual production, excepting the major crops like the mango, banana and citrus. Being very hardy, the custard apple can grow even on slightly rocky situations, on sandy coastal areas, on lateritic hill slopes, or loamy garden soils. It is capable of standing drought better than most fruit trees.

The custard apple is commonly raised from seed in South India and the seedlings attain the bearing stage in three to four years. In the sandy coastal areas and under care, the seedlings have however produced two crops within two years of planting the seedlings. There is considerable variation between the seedlings in size and quality of fruits as well as in yield. Records maintained at Kodur have shown that as against 12 oz. weight of individual fruits and 20 seeds per fruit on selected trees, some of the trees produce a mean fruit weight 6.2 oz. with 38 seeds per fruit. Selection of the best performing and superior fruiting seedling trees and perpetuating them as clonal strains are therefore indicated as desirable. Recent work at Kallar and Kodur has shown that the custard apple as well as the othe cultivated annonas can be easily multiplied by inarching. Grafts of custard apple on bull's heart reached fruiting stage within 20 months of grafting or only 8 months of planting, while the first flowers were observed within 4 months of planting. The precocity induced by grafting is sufficiently striking to merit large scale trial of such vegetative propagation methods.

The fruits of the custard apple are in season from August to December in South India. The low yields of some of the trees are believed to be due to the lack of adequate pollination. An average yield from a good tree may be taken to be 60 to 70 lbs. per year.

Excellent jam and fruit butter can be prepared from custard apple.

The fruits should be picked before reaching the stage of bursting open, and the picked fruits can then be ripened in the store.

A severe form of die-back is reported from sandy and rocky areas planted to the fruit, the remedial measures for which are not yet worked out.

[2. SOUR SOP (*Annona muricata*):—The largest fruits among the annonas are produced by sour sop. They are ovoid or heart-shaped and resemble a small jack fruit with spines on the surface.

The flesh of the fruit is white or creamy-white, juicy, rather cottony in texture when fully ripe and aromatic. It has a peculiar sweetish sour taste and is liked by few persons even when it is crisp just before ripening, while to most it is a fruit of no special merit. As a source for making sherbats, it is reported to be very useful, since the unfermented beverages of the sour sop are reputed to be as good as that of any other fruit of the temperate zone. The sour sop is probably more tropical than the custard apple, and therefore thrives better in the arid plains of South India than in the moist and cooler slopes. It can also stand more moisture at the roots than the custard apple. The propagation is by seed as in all other annonas, but the seedlings reach fruiting age after about four years. It has now been inarched successfully on bull's heart at Kallar, and it is likely that inarching may succeed on other annona rootstocks also. The shy-bearing of the sour sop has also been attributed by some as due to insufficient pollination. The fruits are in season from June to August, i.e., after the bull's] heart season is over and before the custard apples appear in the markets.

3. BULL'S HEART (*Annona reticulata*):—This fruit is also known as bullock's heart or Ramphal and seems to thrive all over the plains as well as on humid hill slopes up to an altitude of about 4,000 feet. The fruits are heart shaped or oval or conical, with white, granular flesh, fairly sweet but called by some as mawkish in flavour. Though propagated by seed, inarching is possible as with other annonas. The fruits are in season from January to May. From a sampling test of these fruits with those of cherimoyer, it was difficult to refer as to which appeals more to the South Indian palate. An individual tree yield at Burliar was found to be about 75 to 100 lbs. of fruit per year.

4. CHERIMOYER:—*Annona cherimolia* has been dealt with separately under hill fruits, while other species of *Annona* are not cultivated in South India.

10. JACK FRUIT (*Artocarpus integrifolia*)

INTRODUCTION:—One of the most popular of the fruits grown in the West Coast, Coorg and Mysore, the jack or as it is sometimes called as jak, is also found widely grown in other parts of South India both in the arid as well as in the humid parts of the hill slopes up to an elevation of about 5,000 feet. Reputed both for its exceptionally large individual fruit size as well as for the large crop weight per tree, the jack is believed to rank foremost among the South Indian fruits in the quantity of food produced per unit area. Though not classed among the choicest fruits, the choicest jacks are deemed among its innumerable patrons in South India to be exquisitely delicious, while the inferior sorts are a welcome food to the people of the lower economic groups, besides finding a ready sale for culinary purposes. Like the banana and the cocoanut, with which it is often found mixed in orchards, the jack serves mankind in several ways. Its leaves are used as dining plates after stitching together or for wrapping certain cereal preparations in the course of baking or cooking. The wood of jack is reputed for its quality and is specially favoured for house building and furniture making. The seeds provide a welcome food to the poor class for a long period of the year, by virtue of its long keeping quality. The flesh or pulp is also put into innumerable uses both in ripe and immature stages in the South Indian households. Jams, beverages, candies, conserves and dehydrated forms are other industrial uses to which the jack can be utilised.

To a certain extent, jack has suffered in the estimation of the public because of the widespread belief that its consumption leads to digestive ailments. This is only partially true, since superior quality fruits in full ripe stage and consumed in moderate quantities have rarely been found to disagree with persons. At any rate, considering the wide and varied uses of the jack, it deserves to be treated with greater esteem than as implied by the commonly applied epithet of " poor man's food" applied to it.

PRODUCTION :—Since the jack is rarely planted on an orchard scale, accurate figures of its production are difficult to be obtained. It is however a popular tree in home yards, in coffee, pepper, areca and cocoanut plantations, in loose jacket orange groves on the hill slopes, and also in other orchards as that of mango, sapota, etc., in almost all parts of South India except on altitudes exceeding about 4,500 feet. On a conservative estimate, the jack trees are believed to exceed 100,000 in number in South India, accounting for a production of fruit every year, as great as that of any other fruit excepting the mango and banana.

CLIMATE AND SOIL :—From what has been stated above, it should be clear that jack grows well both in arid and humid situations, provided the cold is not severe as that occurring in altitudes over about 4,500 feet from the mean sea level. For its optimum growth and fruiting, the jack requires a plentiful supply of moisture in the soil, especially during the dry summer months, but ill-drainage and water stagnation in the soil are very injurious to it. Instances of wholesale casualties in jacks on sites freshly brought under canal irrigation and consequent to the sudden rise in water tables, are not unknown. A rich and deep soil of medium or open texture seems to be the best for the fruit, even though large tree size and good production are occasionally found associated even with poor gravelly and lateritic soils, provided the depth of soil is not wanting.

VARIETIES :—Because of the universal practice of seed propagation, there is immense variation between the trees in respect of fruit shape, size, quality, season of bearing and yielding capacities etc. Occasionally some individual trees of surpassing merit arise in nature and these acquire local reputations. Unfortunately, such trees though are popularly given varietal names, cannot be depended upon to breed true from seed. However, three types are broadly recognised. One is that, which produces tender or soft flesh, quite mushy in texture; the other is with crisp and hard flesh; and the third is a small fruited type going by the name of Rudrakshi, fruits of which are generally of the size of an ordinary pummelo each, and are coated with a smoother and less spiny rind and with fleshy perianth of slightly inferior quality to that of a good jack. In all these three types, individual trees differ from each other in shape and size of fruit, colour of flesh and eating qualities. Experience of the planters on the hills, particularly on the Lower Palnis is that the jacks produced at high elevations such as above 4,000 feet are poor in quality and fit for only culinary purposes. They are also reported to become mushy when ripe.

Recently at the instance of Mr. M. S. Sivaraman, the Director of Agriculture, Madras, a variety known as "Singapore" or "Ceylon" jack has been introduced to South India and is being tried on a large scale. This is reputed to be very precocious, capable of producing the first crop in about 18 months of sowing on the plains and about 24 months on the hills.

PROPAGATION :—Trials on vegetative propagation of jack have been in progress at Kodur, Kallar and Burliar fruit stations for some years, in order to devise a method of perpetuating the superior chance seedlings as clones. Preliminary work done in 1935 at Kodur indicated that inarching was possible, and a couple of grafts raised then are now growing at the Fruit Research Station. As a result of the extended trials undertaken subsequently, it was found that the hard wood cuttings failed to root, as also the layered shoots of various types. Budding methods also have proved of little or no avail, while whip grafting on jack seedlings though provided at the initial stages some indications of success failed to produce successful grafts for planting in the orchard. Further work was therefore limited to inarching which produced a maximum "take" of 30 per cent. only on seedling jacks till about 1946. A more elaborate trial was initiated at Kallar in 1946 to determine the value of inarching on three rootstocks viz., *Artocarpus integrifolia* (jack), *A. hirsuta* (which is a large tree found in a semi-wild state in the West Coast and producing a small fruit resembling a tiny jack and whose fleshy perianth is edible and of fair quality), and Rudrakshi jack. From the inarchings made from July to December 1946 on seedling rootstocks of roughly 30 months of age, a maximum successful "take" of 70 per cent on Rudrakshi, 67 per cent. on jack and 60 per cent. on *A. hirsuta* were obtained.

These results are very promising and show definite possibilities of raising superior clones in future plantations.

PLANTING AND CULTURE :—Considered to be a hardy tree, practically no attention is bestowed on the culture of the jack in South Indian orchards or back-yards. In the West Coast as well as in the coffee, pepper and orange plantations on the hill slopes, the jack is essentially a rain-fed crop, but in drier areas such as those in the Ceded Districts it does receive occasional irrigations and sometimes a light dose of manure as well. The spacing for jack is not uniform, but it is believed that 30 to 40 feet will be found satisfactory, depending upon the site.

CROPPING :—Ordinarily jack seedling trees commence to fruit in about the fourth to the seventh year. The main season for the harvest is from March to July in the West Coast, April to September on the hill slopes, and June to August in the Circars. Occasionally a few trees are found to yield light off-season crops in the rest of the year as well. In some years early harvests have been secured such as even in January in Central Districts. The yield per tree varies greatly in seedling trees, but a fair average may be from 75 to 350 lbs. per year, the range showing the performance in good and bad years, while the maximum may be even double of the latter figure. An individual fruit weighing even up to 80 lbs. is not unknown. In a plantation of 268 trees of good and indifferent bearing capacity at Taliparamba, an average yield of 18.5 fruits per tree was obtained in 1945-46, with a maximum of 250 fruits per tree and a minimum of one fruit only per tree. It was also noted that on the same tree and bearing point, the earlier fruits were in general larger in size than the later ones.

ALLIED FRUITS :—Apart from *Artocarpus hirsuta*, another edible fruited species is also found in semi-wild state in the West Coast, it being *Artocarpus lakoocha.* This is popularly known as monkey jack and produces fruits, each three to four inches in diameter and having edible flesh and seeds of a taste not particularly relishing. The breadfruit is another allied species, which is dealt with separately.

Reference.

Khan K. Fazlulla—Clones of Jack fruit (*Artocarpus integrifolia*). Indian Journal of Horticulture—Vol. IV, June-December, 1946—No. 1-2.

11. BREADFRUIT (*Artocarpus communis*)

This is a handsome tree, producing a plentiful crop of small fruits resembling a miniature jack and used only for culinary purposes. It is at home in the humid tropics on a well-drained soil, being specially in a flourishing condition in the West Coast and in the islands off that coast. It also grows on the humid hill slopes up to about 3,500 feet and in the drier parts of South India as well, if well supplied with water and planted in fairly sheltered spots amidst thick vegetation.

The breadfruit exists in two forms, one of which is seeded and the other seedless. The latter is by far more popular, being suited for culinary use.

The propagation of the inferior seeded form is possible by seed, but the seedless form has to be raised only by vegetative means. Experience at Burliar shows that the best means of multiplying the seedless breadfruit is by root-cuttings, which may be each six to eight inches long and 3/10" to 1¼" in diameter and should be planted horizontally about ½ inch deep in well-tilled beds under partial shade or in the open during the monsoon season. Shoot cuttings fail to root, while the vertically planted root cuttings produce only a low sprouting of not above 20 per cent., as against over 50 per cent. success with horizontally planted root cuttings. Some recommend the dipping of the root cuttings in a 0.2 per cent. solution of potassium permanganate so as to coagulate the latex, before planting. Root suckers arise infrequently and these provided the only planting material at one time in South India.

The trees bear fruits in about six years of planting and produce on an average 50 lbs. of fruits per year, but the maximum may be well over 200 lbs. in some cases.

Reference.

Khan K. Fazlulla—Propagation of Seedless Breadfruit—The Indian Journal of Horticulture—Vol. III, June, 1945—No. 1.

12. PINEAPPLE (*Ananas sativus* syn. *Ananas comosus*)

The pineapple is a crop of some commercial importance in many parts of the West Coast, including the States of Cochin and Travancore, as also on the Simhachalam hill in Vizag District and parts of Coorg and Mysore State. Trials have shown that this crop can also be successfully raised in the rest of the plains of South India, provided good soil, ample irrigation facilities, heavy manuring and good drainage are provided. On the humid hill slopes of South India also the pineapple thrives well and with much less care than on the plains. It is however on the lateritic hill slopes and in sandy or loamy soils of the West Coast where the fruit has greatest possibilities for extension of production. Capable of producing large crops even under rain-fed conditions, the pineapple in the West Coast can be called along with the cashew as a dry land or even as a waste land crop, and can therefore prove to be a profitable means of exploiting the land to the best advantage. The success, however, depends on certain important considerations. Firstly, the pineapple is a gross feeder unlike the cashew, and therefore care is essential to provide adequate quantities of plant food to the crop at different stages of its growth and fruiting. Secondly, the pineapple fruits are liable to serious damage by a host of birds and animals, whose depredations have to be prevented or guarded against. Thirdly, the extent of profits from the farming of this fairly easily perishable fruit is dependent on the availability of cheap, readily available and quick transport facilities or the development of canning and product factories close to the points of production. Subject to these aforesaid facilities, there seems no doubt that South India can well become the leading pineapple producing part of the country, along with parts of Assam. Such a development will be highly desirable, because the extension of pineapple industry will mean not merely one of the best means of augmenting food production from the available land but also of speeding up the policy of industrialisation. The latter is specially to be commended, as India has been one of the growing markets for imported pineapple products from Malaya.

ACREAGE :—According to an estimate by the Madras Marketing Section, nearly 1,400 acres were under pineapple in Madras presidency in 1942 with an estimated annual production of 53,500 lbs. of fruits. This figure possibly excludes the large production in innumerable home-yards in the West Coast. Cochin has reported a little less than 100 acres under the fruit; and more or less the same area may be claimed by the fruit in Travancore, Coorg and Mysore.

CLIMATE AND SOIL :—From what has already been mentioned, the pineapple may be deemed to be a humid tropical plant, though capable of thriving even under arid conditions when irrigated. Where the temperature is excessive, the crop can be grown under partial shade, but in the West Coast such shade is not essential. However, observations show that pineapples raised in widely spaced cocoanut groves or in the alleys of mango orchards during the pre-bearing stages of the mango, flourish as well on the West Coast as those planted in the open; and this fact may possibly be taken to mean that light shade from tall lattice-like canopy or from distant trees are not adverse to pineapple culture in the West

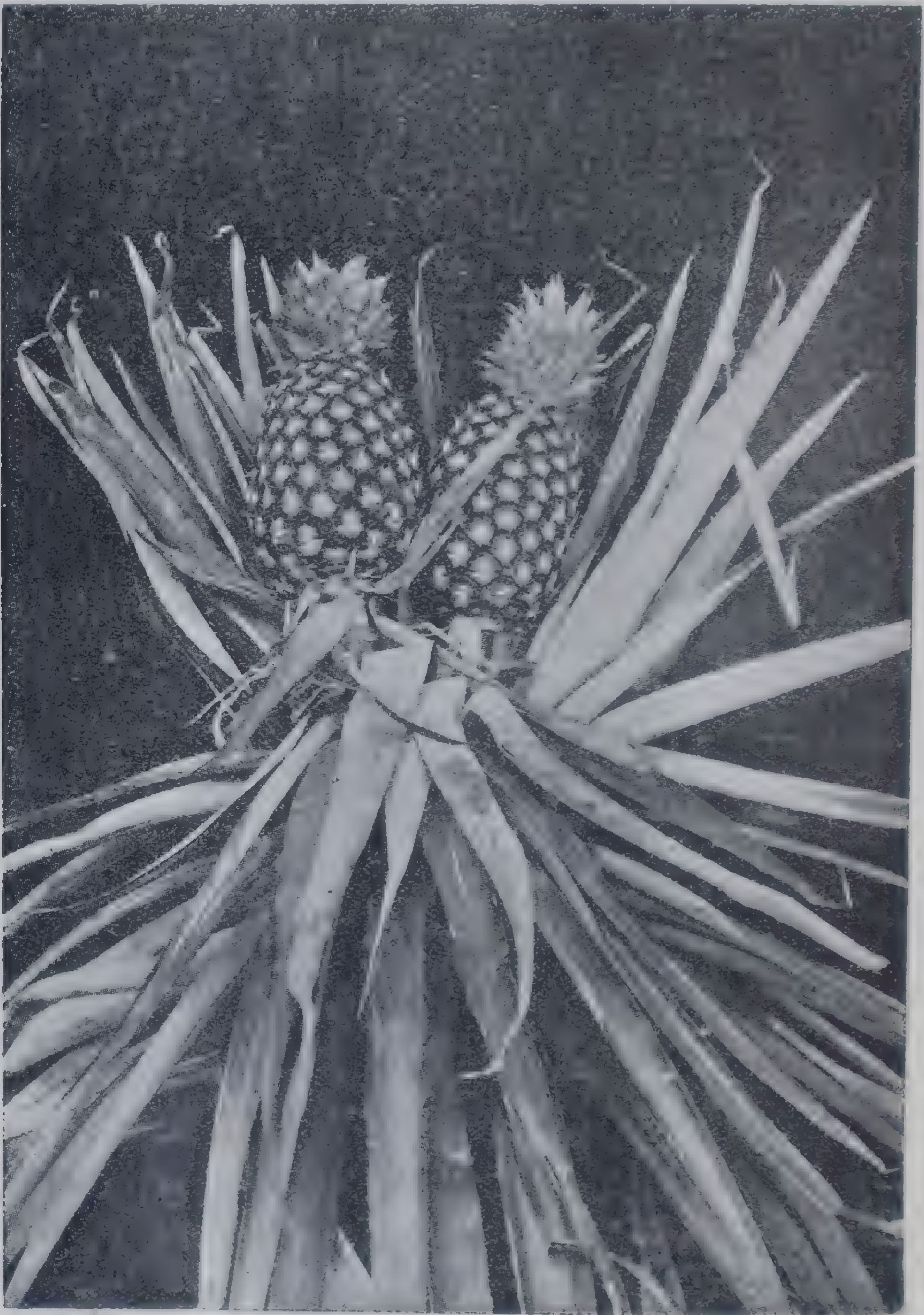

Fig. 107. Pineapple-doubles on a plant.

Coast, where the maximum temperature rarely goes above 102°F. In the drier zones of the province where the maximum temperature ranges in summer between 100° to 110°F., thicker shade and plentiful irrigations are sometimes necessary, unlike in the humid hill slopes. The range of rainfall under which the crop thrives is very wide indeed, being from about 30 inches to 150 inches per annum.

In regard to soil, the pineapple prefers a well-drained soil of fairly open texture, but is adaptable enough to produce good crops under care even in gravelly or clayey soils provided the drainage is satisfactory.

VARIETIES :—Kew is the leading commercial variety of South India and is similar to the Smooth Cayene or Sarawak of Malaya. It produces fruit of 8 to 16 lbs. each and has spineless leaves and a pale flesh. In South India this variety is also known as the Giant Kew, but in Assam the latter name is applied to a different variety, possibly to a larger fruited clonal strain of the Kew. The Kew in South India has a fragrant, crisp and nearly fibreless flesh of agreeable taste. Its spineless leaves are an advantage in large-scale plantations. Its eyes are shallow and small, so that the preparation of the fruit for the table and canning is easy. The second important commercial variety is the Mauritius, which produces smaller fruits of three to five lbs. each, with spiny leaves. Queen is the next popular and resembles the Mauritius in fruit size and often even smaller in bulk plantations. It has deeper and irregular eyes. The taste of Queen is considered the best of all the commercial varieties. It has also some other virtues such as a more attractive flesh colour, uniform ripening habit, relatively heavy suckering tendencies and earliness to reach fruiting stage. Among the other varieties introduced recently, Charlotte Rothschild deserves mention. It yields crops relatively earlier than the above-mentioned varieties except the Queen, produces larger fruits than all except the Kew, and has more juice in the flesh. Though resembling the Mauritius in fruit shape, this variety is more prominently tapering towards the crown. It also develops an orange yellow colour on the rind when ripe. Its aromatic flesh is another desirable character in its favour. In point of taste, however, Queen should be deemed to occupy the first rank, followed by Mauritius, with no perceptible difference between Kew and Charlotte Rothschild.

Propagation :—The pineapple is propagated largely by "suckers" which emerge from the leaf axils near the root. It is however possible to multiply also by "slips" which grow on the stem just below the "apple", from "crowns" which are the tufts of leaves found on the top of the fruit, from "crown slips" which arise beneath or around the "crowns", and from the "discs" cut off from the main axis. The "suckers" are commercially preferred as they produce crop in about 18 months of planting, as against about two years taken by "slips", "crowns" and "discs". The strongest of the "suckers" are usually selected for planting, since they can be set out in the final orchard site straightaway, without having to put them close in a nursery for developing a root system, as in the case of other planting material. The "suckers" are cut neatly with the attached roots and their lower leaves are removed before planting. They are also sometimes dried for a while in the sun before setting out. Where "suckers" are not available in sufficient numbers, the best way possible is to use "discs", as is done in Malaya. In this case, the mother plant is selected from a clump noted for its vigour and high yield, and is stripped off its leaves before flowering. The main axis or the stem is then sliced into sections, each with two to three buds, and these "discs" are then dipped in a weak solution of permanganate of potash for about five minutes, after which they are planted in nursery. When the new plant is about six to twelve inches high, they may be shifted to permanent sites.

Planting :—The suckers with or without drying are planted in well-prepared soil to which heavy applications of well-rotted manure or compost had been added some months previously. The spacing varies from two to six feet between the plants; but in order to allow scope for cultivation in closely spaced plantations, the practice is either to adopt a closer spacing in the row and wider spacing between the rows or to allow a four to six feet path between every three or four rows of plants. The Malaya system of planting with a two and a half feet spacing in the row and five feet spacing between the rows, and with a six feet path at every 100 feet, seems well worth a trial in South India.

Culture :—Since the pineapple benefits greatly from heavy applications of organic manure, particularly in infertile soils of the type commonly allotted to the crop in the West Coast and Simhachalam, applications of well-rotted farm yard manure, amounting to about 25 to 50 cartloads, are given in one or two applications within six to twelve months of planting. Mulching the soil with dried leaves or straw is also done by a few careful growers with obvious advantage, but the regular mulching with such expensive material as heavy asphalted paper, as done in Hawaii, is unknown in South India.

Whether as an intercrop or a pure crop, pineapple cannot be grown indefinitely on the same site. The land is required to be rested after every crop for a long period, or the crop should be rotated to secure satisfactory yields. A resting for at least a year after a crop has been on a site for three to four years, is considered the bare necessity, but on poor soils even six years of resting may not be excessive.

CROPPING :—The plants begin to give out the first fruit yield from 12 to 18 months of planting the suckers. They will continue to yield on the same site for two to three years thereafter, after which there will be an appreciable decline. In case the pineapple is grown as intercrop, it should be removed within seven to eight years of the planting of the orchard, since after this the shade of the tree fruits may be too dense for the pineapple to prosper. Records maintained at Hessarghatta Fruit Station in Mysore showed that the maximum weight of the individual fruits was only 6.8 lbs. in Mauritius, with the mean weight of 3 lbs. per fruit. With Queen the mean fruit weight was only 1 lb. 1 oz. The mean yield per acre in South India may be about 5.5 tons per year, while the maximum may go in Kew up to even 10 tons. This yield is far below the yield of 30 tons per acre reported from other countries, and is explained mainly by the fact that the South Indian commercial pineapple is primarily a rain-fed crop with little care bestowed on its planting or tending. The crop in the Circars comes to harvest from June to August while on the West Coast it is from April to June.

PRODUCTS :—Excellent products of pineapples, such as juice, jam, marmalade, candy and canned pineapples have been prepared by the author at Kodur. A pineapple eye-extractor has also been devised for extracting the eyes expeditiously and neatly with minimum loss of juice and edible matter. It is likely to be of great help in preparing the fruit both for table and product manufacture. Fibre of good quality can also be prepared out of the leaves of pineapple, although its extraction may possibly be uneconomic, till a mechanical extracting machine is devised.

PESTS AND DISEASES:—No pests or diseases of any great importance have been reported on this crop.

List of References

1. Naik, K. C.—Some Useful Orchard Equipments Devised at Kodur—Madras Agricultural Journal, March, 1941.
2. ,, Fruit Personalities—Pineapple, *Mezhichelvam* (In Tamil), Madras, July, 1946.

13. SPONDIAS

Some species of *Spondias* are found as stray trees especially in the West Coast. One of these produces plum-like, greenish, oval to ovoid fruits, each two to three inches long, which assumes an yellowish tint when ripe and has each one large seed. The fruit is acid to sub-acid in taste and is used for culinary preparations, especially in preparing fish curries and for pungent soups. The propagation is by seed.

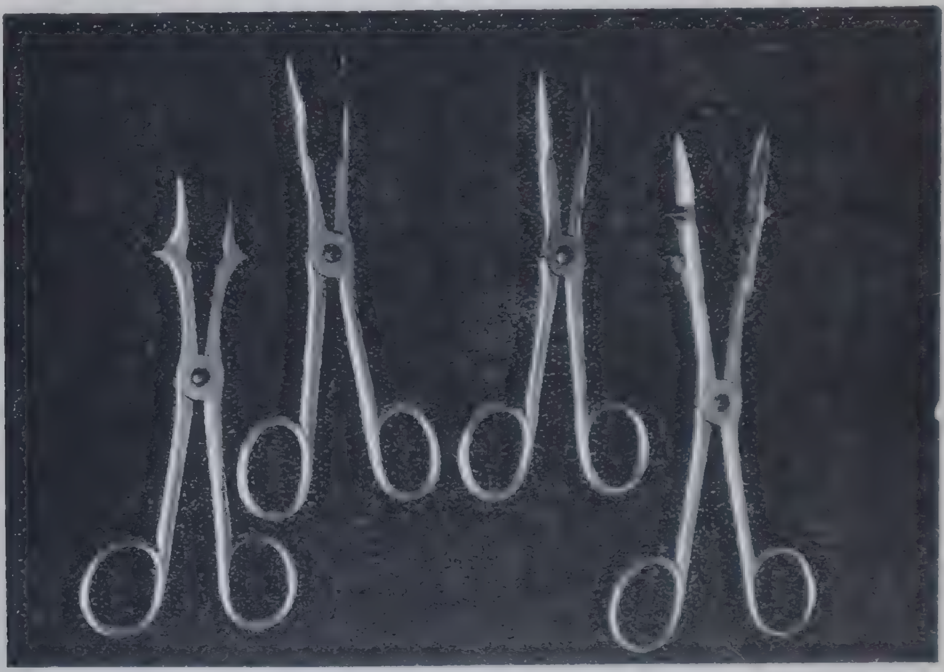

Fig. 108. Pineapple "eye" extractors of different types

CHAPTER VIII

FRUITS OF THE PLAINS

To bring the vast undulating ground dotted with hills and valleys, which form the general feature of the major portion of South India, under one heading is apparently unjustifiable. In consonance with the division so far adopted in this book, a separate zone designating those areas suited for all fruit crops other than those on high altitudes of exceeding about 4,500 feet and those that commonly thrive on the lower ranges of the hills under relatively more humid conditions and between roughly the altitudes of 1,000 to 4,500 feet, seem necessary. This zone representing both the heavy and low rainfall tracts of South India has been conveniently referred to as the plains, even though in a literal sense the immense area brought under this zone is not by any means a vast level expanse, more or less analogous to the Indo-Gangetic plains of North India. The artificial heading is retained in spite of its limitations, for want of a more appropriate and expressive word.

On the same grounds, the fruit crops dealt with in this chapter may need an explanation. While it is the practice all the world over to treat all the perennial fruit and nut crops together, because of the fact that they are fundamentally alike in regard to their treatment in the hands of the scientific worker, student and the grower, yet such plantation crops like cocoanuts and arecanuts have to be left out of this chapter on some important and special considerations. It is true that cocoanuts are grown primarily for their edible kernels and to a small extent for the refreshing beverage which their tender nuts provide. However, this crop is generally treated as an oil-seed crop by the Agricultural Departments in South India and have therefore been studied and worked upon by workers other than those in the fruit sections. The arecanuts also have not been brought within the scope of the activities of fruit workers.

There is yet another class of plants which can be claimed to fall into more than one sphere of research activity. Tomato and several cucurbetaceous crops are instances of those which are commonly dealt with as vegetable crops by all the Agricultural Departments, no doubt on the plea that these crops are not all perennial and their produce is not largely used as table fruits. The musk and water melons are treated differently, since in spite of their being not perennial crops, they are grown entirely for use as table fruits. The drumstick and tamarind are also excluded from this chapter on the grounds that they are grown mainly for culinary purposes.

The selection of crops in this chapter has therefore been restricted only to such perennial fruit crops as guava, ziziphus, falsa, date, carissa, palmyra, woodapple, bael, opuntia and *Inga dulce*. fruit-cum-nut crops as cashew and country almond, and annual fruit crops as musk melon and water melons.

1. GUAVA (*Psidium guajava*)

The guava is a tropical fruit that is adaptable to a diversity of soil and climatic conditions and is hardy enough to withstand considerable neglect. Owing to these features it is popular in all parts of South India more as a home yard fruit than as a commercial one, excepting in a few localities. The failure of the fruit to attain commercial significance is partly due to the fact that the fruit is never esteemed as of superior type for dessert purposes, nor any great demand exists in this region for any of the various guava products. To an extent the failure of the region to grow superior varieties of the guava is also responsible for relegating the fruit to an insignificant corner in the home and commercial plantings.

PRODUCTION :—It is only in the Northern Circars, commercial guava culture has been attempted with some vigour. The estimated area in that part of South India is somewhere near 2,500 acres. About 50 acres are also planted to this fruit near Hindupur in Anantapur district. Elsewhere in South India the guava is rarely grown in fields over about half-an-acre each in individual holdings.

CLIMATE AND SOIL :—An arid and hot climate seems best suited for the fruit, though it is found as stray trees all over the humid and arid zones of South India upto an altitude of about 3,000 feet. The commercial guava plantings in South India are largely restricted to high-lying sandy soil stretches of the river beds or banks, where alluvial soils are intermixed with large amounts of sand. This does not mean that the guava is not adaptable to other soils. Any well-drained soil of open texture, and that is not classed as stiff clay, seems to permit the guava tree to grow and fruit satisfactorily provided there is at least about four feet of soil depth of uniform texture. Even infertile and rocky slopes of small hillocks are found satisfactory, provided good organic matter and sufficient moisture supply are made available to enable the trees produce good fruit crops regularly. In the absence of any attention, the guava may not show much apparent distress, although the yields may be low.

VARIETIES:—Under commercial cultivation in the Circars, only the seedling trees are raised and these are broadly of two groups—one being white and the other red-fleshed. Majority of the trees on the banks of Kistna and Sharada rivers are of white-fleshed group. Because of seed propagation there is considerable variation in the plantations, in which the growers, however, recognise certain distinct forms, each of which is designated by a local name. Recently, the vegetatively propagated varieties are gaining popularity in certain home orchards as well as in a few large-scale plantings in Mysore State and parts of Anantapur district. From the trial of several imported varieties from the United Provinces at Kodur, the following promising ones have been selected as the most suitable for South Indian plains.

1. SMOOTH GREEN—produces medium-sized fruits with rough and shining skin and firm, white flesh of good flavour. Seeds are few and small, which are fairly hard.

2. ALLAHABAD—produces large fruits with yellowish white skin and white flesh of soft texture and pleasant flavour ; seeds few, of medium-size and fairly hard.

3. RED FLESHED—produces medium-sized fruits of yellowish-white skin and red flesh, which is firm and of good flavour ; seeds many and fairly soft.

4. NAGPUR SEEDLESS—fruits small to medium with smooth skin of lemon yellow colour. Flesh is white and soft and of delightful flavour ; seedless fruits are often irregularly shaped like other seedless varieties.

5. SAHARANPUR SEEDLESS—medium-sized fruits of lustrous, lemon-yellow rind colour and white flesh. Flavour delightful, and fruits are seedless.

6. HAFSI, CHITTIDAR AND SEEDLESS—are the three reputed varieties from Allahabad, all of which produce fruits of medium to

large size and of smooth skin and round shape. The latter two are almost alike and have white flesh, while the Hafsi has red flesh. All are of good taste and flavour.

7. KARELA—produces pyriform fruits with rough skin and white flesh of good flavour.

PROPAGATION :—As already pointed out, seed propagation is the rule in South Indian commercial plantations, but of late the vegetative reproduction of superior varieties by grafting, layering or root-suckering are becoming increasingly popular. Seeds germinate rather slowly, often taking over a month. A year from the date of sowing, the seedlings are usually transplanted to the orchard sites, while some prefer to transplant the seedlings once before to nursery beds when about 3" high. Layering is the most convenient and is more extensively practised in nurseries than other asexual methods. Suckers occasionally arise and these can be lifted out and planted if they are taken from layered trees. Where the orchards are planted to grafts on inferior fruit-bearing rootstocks, the root suckers are valueless except for use as rootstocks. It is possible to induce root sucker formation by exposing a few surface lateral roots up to a few feet away from the trunk and wounding these roots at suitable intervals. If the wounds are covered over immediately by soil and the soil is kept moist by timely irrigation, roots and vegetative growth result at the wounds, leading to the production of suckers. Inarching on seedling guava is also possible and is practised in some nurseries.

CULTURE :—The seedling trees on the river banks are usually planted with a spacing of about 15 feet. Such trees rarely receive any irrigation except during the first year of planting, and during the hottest periods in subsequent years when the trees show signs of wilting. Manuring with well-rotted farm yard manure or compost is done during the monsoon season regularly, as without this the trees are incapable of bearing good crops. Six cart loads of either of the above organic manures along with about two cart loads of sheep dung are commonly applied per acre in each of the first two years, and these doses are doubled about four years later. No pruning is given excepting for the removal of dead shoots. The layered trees or grafts are planted in good garden soils, and are spaced more widely than the seedlings, a 20-to-25-feet spacing being popular. The irrigation and manuring as well as soil tillage to keep off weeds are done more regularly in such soils than on the river banks. However, no pruning on any systematic scale is done even here, nor is the Bombay practice of bending the branches and tying the neighbouring shoots to force buds to growth and produce a larger crop, is in vogue.

At Kodur it has been found that the guava lends itself well for growing as cordons. Cordon-trained guavas occupy little space but are very attractive and useful to screen off parts of an orchard from each other or to enclose any permanent structure. Such cordons look green and fresh all through the year and also yield good crops under care.

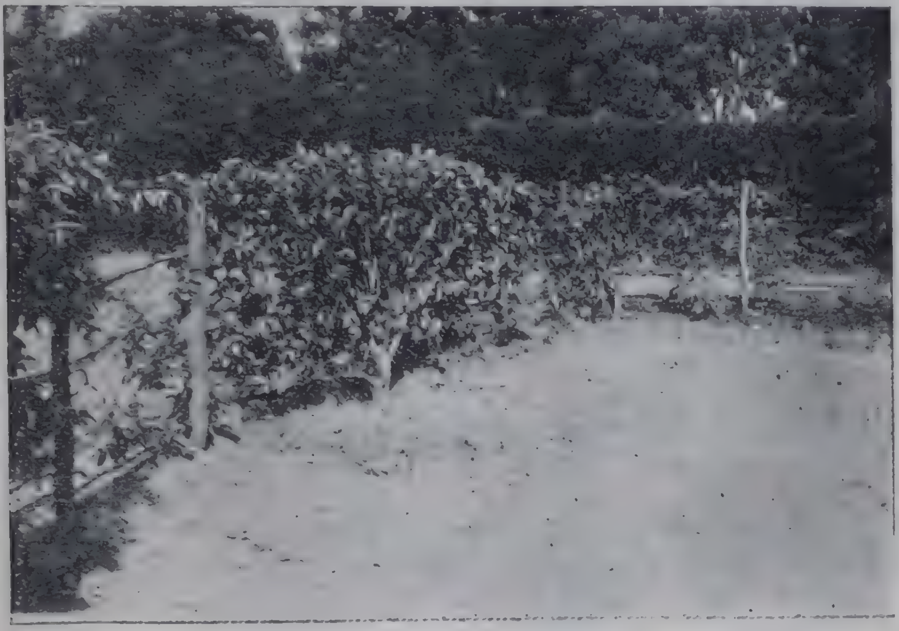

Fig. 109. Guavas trained on wires.

Cropping :—Guava produces crop from the new shoots emerging from older wood. When the last season's shoots are cut back to one to three buds, the dormant buds in the basal parts are stimulated into growth activity and some of these bear fruit buds. Such topping back of past season's growth seems to be useful particularly in cordon-trained guavas to enhance yields.

The seedling guava plantations when unirrigated, reach the bearing stage usually in about four years and produce crops mainly in two seasons—June-July and October-December. On the banks of Kistna river, the June-July crop is risky or uncertain owing to the floods. In such an event, the second season crop in Guntur and Kistna districts often extends to February. A light third crop also is harvested from February to April and has a ready demand fetching good price. The estimated yields from seedling plantations are from

100 to 300 fruits per tree in June-July and 300 to 500 fruits in October-December. Some of the vigorous seedling trees may even produce a few flowers in the first year of planting, but they produce a commercial crop only three or four years after planting, continuing to crop well for about 30 years thereafter.

The grafted and layered trees are found to bear flowers at Kodur once in June-July and again from January to March. Over 800 fruits per year have been harvested from a single, about eight-year-old tree of Smooth Green at Kodur. Both the layers and grafts have commenced to fruit in about the third year. The peak harvest season at Kodur was from June to July. An annual yield of over 700 fruits per tree of Red Fleshed variety and of 500 fruits of Allahabad varieties as against about 125 fruits per tree of seedless varieties, have been recorded at Kodur. On cordons, the Hafsi, Chittidar and Safeda varieties have yielded only about 200 fruits per year per tree.

PRODUCTS :—Guava is unrivalled for jellies and is also popular as a stewed or preserved fruit. Guava fruits can also be dehydrated easily to yield a flour fairly rich in vitamin C content. At Kodur, it took about 20 hours to dehydrate Nagpur Seedless fruits at 120° to 130° F. The yield of flour worked out roughly to 25 per cent of the fresh fruit weight. The vitamin C content as analysed at the Nutrition Institute, Coonoor was found to vary from 280 mg. per 100 gm. of Smooth Green to 580 mg. per 100 gm. of Allahabad fruits. The white-fleshed guavas are reported to be slightly richer in ascorbic acid content than those of red or pink-fleshed fruits. It is further reported that the skin has the highest vitamin C content, and this progressively decreases as one proceeds towards the seed core. The eating of guava fruits with the skin intact is therefore seen to be advisable.

ALLIED PLANTS :—The strawberry guava (*P. cattleianum*) is a small shrub with ornamental, glossy leaves, bearing fruits of very small size, fit for jelly. It is already dealt with under Hill Fruits. The hill gooseberry—(*Rhodomyrtus tomentosa*) is another plant of the guava family, which is also a shrub found on elevation of about 5,000 feet in South India, and which yields edible fruits of low quality.

PESTS AND DISEASES :—Birds are the only serious menace to guavas and these can be kept off by covering the bearing trees with field nets of about nine inch meshes.

List of References

1. Syed, Ibrahim—Survey of Guava Cultivation in the Circars; Mad. Agri. Journal, October, 1943.
2. Naik, K. C.—Fruit Personalities—Guava—*Mezhichelvam* (In Tamil), Madras, June, 1945.

2. ZIZIPHUS OR JUJUBE (*Ziziphus jujuba*)

The superior varieties of this fruit as well as the inferior wild forms are seen to flourish all over the hot and dry zones of the South Indian plains, the latter especially constituting an invariable accompaniment of the vegetation in forests, the scrub jungle areas, the almost barren grounds, and even the partially water-logged spots or the banks of the innumerable running brooks. With certain species of *Acacia,* the *Jujube* and the allied species of this fruit can be deemed to be the hardiest of the xerophytic plants found in the warm, arid parts of South India. While the fruits of cultivated varieties are sold even in urban areas, those of the wild forms are only collected by the poorer classes in rural areas for consumption.

PRODUCTION :—The area under the superior cultivated varieties of jujube covered a few years back over 500 acres in and around Panyam in Kurnool district and in parts of Cuddapah District. Of late, however, due to severe incidence of fruit fly on jujube the area is showing a declining tendency.

CLIMATE AND SOIL :—The jujube does not seem to be fastidious regarding the soil and can even tolerate some alkali ; but there is no doubt the tree responds well to good soil and care, even though it can grow on practically any soil in the warmer and arid zones, provided the soil is capable of accommodating any crop. Its amazing adaptability is seen from the fact that trees are found to grow even in water-logged sites as well as in the dry areas with water table several scores of feet below the surface and with no artificial irrigation at all.

VARIETIES :—There are several varieties under cultivation, each with a local name. Of these, a conical fruited variety of the size of a plum, going 36 to a pound and having a very sweet taste and soft pulp is found to be the best. This variety yields over 175 lbs. of fruit per year per tree, but is subject to fruit fly maggot attack in a severe form. Another round-fruited variety with fruits of a slightly larger size, about 20 only going to a pound is the next best in taste, but is also highly susceptible to the pest.

Propagation :—The propagation of jujube is from seed; but for commercial planting to superior varieties, budding is preferred. Top-working of inferior trees by budding is also easy and can be done advantageously to increase the production of finer sorts. The rootstocks may be jujube seedlings or of any of the allied species such as *Z. rotundifolia, Z. oenoplia and Z. rugosa.* The seeds of all species germinate slowly and often produce scraggy or crooked plants, which transplant with difficulty. It is therefore best to sow the seeds in sites where the budding may be done later *in situ.* The seeds may be cracked slightly to facilitate quick germination. Ring budding is possible, but shield budding is largely preferred.

Culture :—The jujube rarely receives any culture or pruning. However, since the trees are scraggy and shapeless generally, some corrective pruning to give a shape to the tree seems desirable. The budded plants grow into large size, so that a spacing of 35 to 40 feet seems necessary.

Cropping :—The budded trees produce crops within two years of planting. On top-worked trees as well as in vigorous budded trees, some fruits may be secured even in the first year. The yield of a full-grown tree is enormous, 5,000 to 10,000 fruits per tree per annum being not uncommon. The fruits are in season from December to April.

Pests and Diseases :—The fruit fly—*Carpomya vesuviana* is the major pest. The maggots of these feed on the pulp of the fruit. Trees seem to differ to a degree in the resistance to this pest. Raking of the soil under the trees to destroy the pupae has been recommended. Selection of resistant trees and establishment of clones is another possible line of improvement.

3. FALSA OR PHALSA (*Grewia asiatica*)

This fruit is a relatively recent introduction, but has been found to thrive very well in the arid and warmer parts of South India. It is a small-sized tree with purplish berries containing a large seed each. Used as a dessert fruit primarily, with or without the addition of salt and other spicy ingredients, it also makes a delicious and cooling beverage. The fruits are easily perishable and have therefore to be sold locally. The seeds are sown during the monsoon and the seedlings can be transplanted a year hence. They are set out at a spacing of 10 to 15 feet. Being drouth-resistant, no irrigation is necessary; and it can also grow even on relatively poor soils. Unlike in the Punjab, the falsa is not pruned severely to a bush form. The seedlings bear fruits in a year or two after planting. The fruits are in season during summer months. The average tree yield is 20 to 25 lbs. of fruit per year.

4. DATE PALM (*Phoenix dactylifera*)

The wild date—*Phoenix sylvestris* is found in all the dry districts of South India and is as hardy and adaptable as the *Ziziphus jujuba* or other species of *Ziziphus*. Although its ripe fruits are edible, they are in no way comparable to the delicious fruits of the superior varieties of *P. dactylifera* or what is popularly known as the Mesopotamian date. *Phoenix farinifera* and *P. pumilis* var. *pedunculata* are two other wild species of the date palm, which also yield edible fruits but of little or no commercial value.

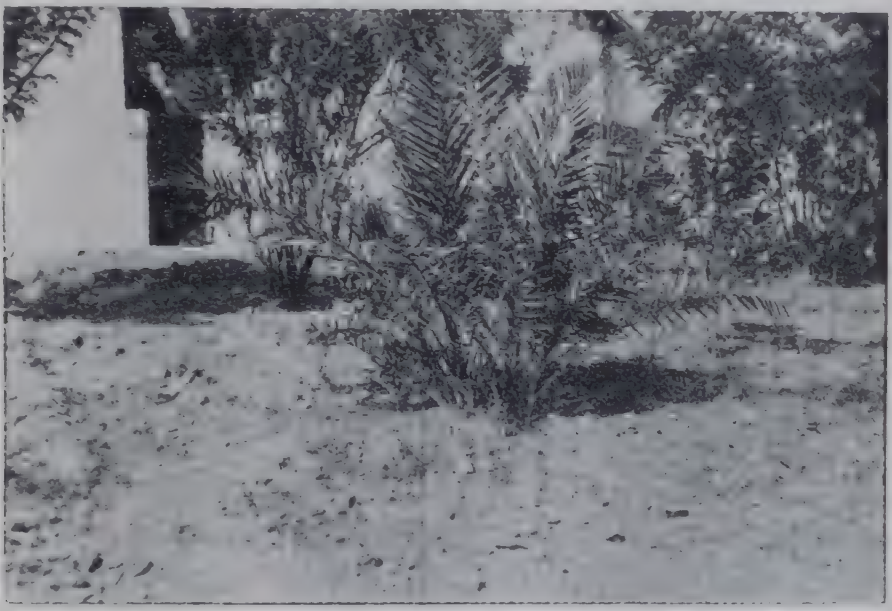

Fig. 110. Mesopotamian date palms introduced recently to Kodur.

Like all these species, the cultivated date relishes a hot and dry climate with ample moisture at the root. Unlike the wild palms, however, it has to be commercially propagated only by off-shoots or suckers. None of the introduced superior varieties like Hillawi, Khudrawi, Zaidi and Shamraon have yet fruited in South India to adjudge their merits. The date is a dieocious plant and requires pollination to secure good fruit set. The palms produce flowers in 5 to 8 years of planting the suckers, and are planted with a spacing of 15 to 20 feet. At the time of flowering the staminate flower clusters are brought from male palms and are taken to the female palms close to the flowers to be pollinated. The former are then shaken over the spadix and afterwards tied to the spathes. The wild dates mature fruits from April to June in South India, i.e., before the rains commence. If the introduced Mesopotamian varieties also mature crops in these months, it will be ideal, in that the crop will be free from the risks of damage by rains. Since all the fruits do not ripen at one time, picking is done once in about three days. A full-grown palm may yield about 12 bunches of roughly 40 lbs. in weight, as is seen from the experience in other parts of India. To protect the fruits from damage by birds, a paper or gunny or matting cover is given to the fruits before ripening stage is reached.

5. CARISSA (*Carissa carandas*)

This is a plant found in the dry forest areas and occasionally also in the hedges and in the form of individual shrubs in gardens and orchards. It produces fruits which are green when immature and purple when ripe, and which are used largely for pickling and for making preserves. A jelly also can be prepared out of the fruits. Natal plum—*Carissa grandiflora* is an allied species, which is a smaller shrub with deeper green leaves, bifurcated thorns and larger fruits of dark red colour when ripe. With its white flowers and red fruits, the bush is of ornamental value, besides being put into the same uses as *C. carandas. C. spinarum* is another thorny shrub with irregular branching habit, found in scrubby forest areas in dry parts, producing dark purple edible fruits. *C. pancinervia* is another allied plant yielding also dark purple edible fruits. The propagation of all of these is from seed.

6. PALMYRAH (*Borassus flabelifer*)

This is a common feature of the South Indian plains both in heavy rainfall and arid parts. On the aggregate, the palmyrah palms in South India should be numbering some millions. The ripe fruits of this graceful palm are eaten by the poorer classes, while its young nut kernel is more widely relished for its delicate flavoured, translucent, milk-white flesh. Its leaves are used for thatching, as country umbrellas and for lifting water, while the stem is used for house constructions and as supports or water carrying tubes. In pre-prohibition days this palm was an important source of toddy and to some extent of a sweet but unfermented beverage. Palmyrah jaggery was also a popular sweetening agent in villages. The edible part of the germinating seedling is also a relish in most parts.

Walking sticks made of old palm trunks is a priced article. As a source of fibre the palmyrah is of some importance in South Indian economy. The propagation is from seed; and the palms produce crops after about 15 to 20 years, giving on an average 50 fruits in six to 12 bunches per year. The tender fruits are in season from April to May, while the ripe fruits are available from July to September. According to Mr. K. G. S. Bhandary, the District Agricultural Officer, Mangalore the male trees number more than the female trees in a seedling grove of palmyrah. In the West Coast he reports that the palms flower from July, and the fruits are available from November to March. The average yield of toddy, as per his report is about four pints per palm per day, though some palms may yield upto 12 pints each. Like the wild date and ziziphus, the palmyrah is a hardy plant tolerating even some amount of alkali or wet feet, and consequently figuring prominently in the South Indian landscape either as spontaneously originated plant or as a result of planned action by the growers.

7. **WOODAPPLE** (*Feronia elephantum* syn. *F. limonia*)

This is a forest tree found in dry areas of South India. Its fruits have an edible pulp of fair quality enclosed in a hard rind. Occasionally the tree is grown in orchards as stray trees, when about a 30-feet spacing is given to them. The woodapple is propagated by seed. A good jelly can also be made out of this fruit.

8. **BAEL** (*Aegle marmelos*)

This is a thorny tree also found in dry forest areas and occasionally grown in orchards for its ripe fruits, which are larger than the woodapple but are also edible and used for making a beverage. The tree is found in Shaiva temples and the fruit is believed to be a specific against dysentery. Like the woodapple, the rind of the fruit is hard; and the tree is grown with about 30 feet spacing in the orchard. This tree is also raised from seed and the trees commence to fruit in about six years. A cold jelly of pale amber colour can be prepared from the fruit. The pulp of the fruit is smeared on the head by some persons as this is claimed to have the cooling effect. Small fruits have been used for preparing snuff boxes with or without gold or silver trippings. The trees flower from July to August and the fruits ripen eight to nine months thereafter. The yield may be from 200 to 800 fruits a year.

9. PRICKLY PEAR (*Opuntia dillenii*)

The prickly pear is more a weed than a fruit crop, and thanks to the ravages of the cochineal insect it has nearly passed out of the South Indian landscape. Being a drouth-resistant, xerophytic plant it is grown on soils of varied type all over the dry zones. It yields fruits which are eaten by the poorer classes.

10. INGA DULCE

A popular thorny hedge plant of the dry areas, this also yields pods with edible pulp, which is in season from April to May. The propagation is by seed. The pods are borne only when the plants are left untrimmed.

11. CASHEW (*Anacardium occidentale*)

Like the custardapple, wild date and jujube, the cashew is so completely naturalized on the western and eastern coasts of South India up to about an elevation of 2,000 feet, that it is now classed more as a waste land crop than an orchard fruit or nut crop. The readiness with which the cashew grows and fruits in a semi-wild state, has not prevented it from becoming one of the important economic crops of South India. Rated as one of the rich sources of vitamin C, the cashew apple, which is really the swollen peduncle and disk with the kidney shaped fruit or cashewnut attached to the lower end, is a valuable raw produce for a potential fresh fruit beverage and vinegar industry. Its fermented beverage was also an important article of trade before prohibition became the policy of some of the Governments. The kernels are also a nutritive and tasty food, with a high protein and fat content, besides being rich in phosphorous, iron and vitamin A and with small amounts of vitamins B^1 and B^2. They are popular for consumption as such and for use in cakes and sweets. The kernel and shell oils of the cashew have long been known to possess valuable properties and economic importance. The oil is said to form 25 to 30 per cent by weight of the shell and is reddish brown in colour containing mainly anacardic acid and cardol. It is used largely as a preservative for boats and nets by fishermen in South India and is further believed to be a good protection against white ant attack to furniture. In the United States of America, this oil has been used for preparing varnishes, moulding compositions, inks and insulating equipment. The kernel is reported to contain about 40 per cent of oil, which is said to have a nutritive value equal to almond oil and superior to oilve oil. The edible kernels have attained considerable importance, accounting in some years for an export trade of about Rs. 10,000,000 per annum mainly in the form of salted and processed nuts. This development has led to the establishment of several curing and shelling factories in South India as well as to the popularisation of these in the form of cottage and medium-scale industries. The remarkable penetrating aroma of the apple may also lend it suitable for the preparation of jam and candies. The wood of the cashew is also in demand as fuel and to some extent for constructing boats.

PRODUCTION :—According to the .Agricultural Marketing Adviser to the Government of India, the estimated area under the cashew in Madras Presidency for 1934-44 is about 45,500 acres, while Travancore and Cochin States claim about 40,000 acres and 8,300 acres respectively. In Madras, Malabar and South Kanara districts together account for about 60 per cent of the annual production, with the rest distributed in Vizag, South Arcot, Trichinopoly, Tanjore, East Godavary, Chingleput, Guntur, Cuddapah and Nellore. Mysore is also growing this fruit and nut crop in forest areas on about 500 acres. During 1936-37, 10,192 tons of kernels were exported from India, of which South India contributed 8,799 tons valued at Rs. 9,971,567. These serve to indicate the importance of the cashew in South Indian economy and also the possibilities for extension of the industry in the vacant or uncultivated areas, where the cashew can be raised at little cost but with some profit. Even at present, India accounts for more than 90 per cent of the international trade in cashew kernels ; and there are vast possibilities to extend the trade by popularising this nutritive food in all parts of the globe.

CLIMATE AND SOIL :—Even though it is possible to grow the cashew up to an elevation of about 3,000 feet in South India, its performance seems at best in the coastal and inland areas of the plains below about 1,500 feet from the mean sea level. A variation of rainfall from 20 to 150 inches does not seem to make a great deal of difference to the cashew, provided the soil is very open and well-drained. More than the annual precipitation, the important factor that influences the yields in cashew seems to be the texture, depth and fertility of the soil. While it is a crop that can grow and fruit even on rocky and poor lateritic hill slopes of the West Coast, where it is in fact found in greatest abundance at present, better growth and yields are found in soils of a loamy texture and good depth.

VARIETIES :—Because of seed propagation, the cashew exhibits immense variation between seedling trees in respect of all economic characters such as yield, apple colour, taste, form and size; nut size, shape, contents etc. The innumerable seedling forms are often designated wrongly as varieties, but none of these can be reproduced except vegetatively, which methods have yet to be attempted on a commercial scale. At Kodur the individual tree yields in a seven to eight year old seedling plantation have varied from 50 to 1,250 nuts or apples in 1944 and 12 to 1,460 nuts or apples in 1943, while at Taliparamba it has been recorded in 1942-43 that although the mean yield from a plantation of 380 trees was less than three lbs., the maximum individual tree yield was as high as 21 lbs. of nuts. Much higher yields up to 100 lbs. are also reported from stray trees elsewhere in South India. Such variations in seed progeny are also exemplified by other characters concerned with the morphology of the apple, nut and tree, so that a description of the numerous forms has no meaning or practical significance at the present stage.

PROPAGATION :—The almost universal method of propagation in cashew is by seed. These are sown either *in situ* or in pots or seed beds for transplanting the seedlings to the permanent sites within one to 12 months of sowing. The sowing *in situ* is largely preferred, since the cashew resents the transplanting operation and rarely succeeds when lifted with naked roots. When sown *in situ*, it is usual to give a thorny cover or protection to the nuts for the first few months to prevent damage to the cotyledons from the animal pests. Trials conducted at Kodur have now established that the cashew can be successfully raised by several vegetative methods, so that the perpetuation of clonal strains of high commercial value is now rendered possible. Layering, side-grafting, inarching, patch and shield budding are all found possible, but layering and inarching seem to be the best up to this stage. The layers root readily in about two months, if performed in a rainy season. To avoid root injury, such layers are best raised in pots, so that the separated layers can be set out in the final site with the ball of earth around the roots intact. Trials on layering of the cashew at Taliparamba in 1945-46 have also proved very encouraging, producing a successful rooting in 40 per cent of the treated shoots, and an individual root length of 18 inches within about two months in shoots layered in December 1945. For raising seedlings, preliminary trials at Kodur have revealed that, the method of sowing the nuts vertically at a depth equal to the length of the nut, is superior to other methods. A year after the sowing, the seedlings are fit for inarching. A 100 % success by layering and an almost equally high "take" by inarching are found possible at Kodur. Cuttings and raising of root suckers have also been tried at Kodur but with no success. Budding was more encouraging, while side-grafting was distinctly promising though not to as great an extent as inarching and layering.

PLANTING AND CULTURE :—On good soils the cashew grows to large size, necessitating a spacing of about 40 feet, but on barren, lateritic and rocky soils more than 20 feet spacing may be unnecessary. Neither irrigation nor manuring, grove culture nor pruning are practised systematically in cashew plantations.

CROPPING :—The cashew produces flowers in terminal panicles like the mango. It is also polygamous like the mango, both the staminate and the bisexual flowers occurring in the same panicle. The cashew seems adapted for both self and cross-pollination. The earlier and the stigma extending above the anthers. No definite correlation seems possible between fruit set and proportion of perfect flowers in a given tree. From the observations made so far, the cashew seems adapted for both self and cross-pollination. The number of perfect flowers appears low in panicles which open their flowers early in the season. In nature, the number of such flowers which set fruits is believed to be very small, not exceeding about one per cent. In controlled pollination, however, successful fruit set was secured at Taliparamba up to 13.55 per cent. From the fact that stray cashew trees are capable of setting large crops, even when located far away from other trees, it is surmised that the cashew is self-fruitful. From the date of pollination to that of ripening of the apple, it has been found to take about 62 days at Taliparamba in 1946.

It is not unusual to find with the cashew a poor fruit set following a good show of blossoms in some years. In this respect as in many others, the cashew exhibits similar features as the mango in South India. The above feature has been popularly attributed to unfavourable weather conditions during the blossoming and fruit setting periods. Whatever that may be, it seems clear that weather conditions prior to blooming do not exert similar influences on the mango and the cashew. For instance, a prolonged wet weather preceding the blooming season. such as that from October 1946 to January 1947, is found to inhibit flowering in mango but foster a good blossom crop in cashew, though delaying the blossom emergence by a few weeks. The first bearing is secured from the cashew in about three years of planting the seedlings or of sowing, while a full yield may be expected in about eight years. There are however instances when plants of about 18 months of age have also borne a small crop. Flowers appear from November to February and the fruits ripen from March to May, with the season advancing in years when heavy rainfall is experienced in November-December. A few stray fruits and nuts may be obtained during the rest of the years also from a few trees.

The mean tree yields have already been shown to vary considerably from less than three lbs. to 100 lbs. per annum.

The apples, being considered to be generally of low market value, are usually allowed to ripen on the trees and to drop off ; and the nuts are thus collected daily. A good shaking of the branches also helps to make the ripe fruits shed. In seasons of high prevailing prices for the nuts, picking of immature nuts is often practised, which adversely affects both the quantity and quality of the yields. Immature nuts however are in some demand for use of the kernel in curries and some forms of confectionary.

Preparation of Nuts :—The nuts are separated from the apples and are dried in the sun for a day or two. This drying helps to prolong the keeping quality. Before the nuts are shelled, they may be either fully dried or roasted. Roasting is done more extensively, since this facilitates the extraction of kernels and also adds flavour to the kernels. Improved methods of roasting have now been devised by some firms in place of the old method of roasting in open pans over circular furnace, so that now this operation is done without the smoke from the burning nuts being a source of danger to the health of the workers. The new process also renders possible to collect the maximum amount of shell oil and to secure kernels of uniform quality. The new roasting process is done either with the use of rotary cylinders or in oil baths. These are patented devices adopted by private firms. The shelling is done by hand and soon after roasting. The brownish thin skin which adheres to the kernels are also removed, after the extracted kernels are dried in the sun or in hot air chambers. The peeled kernels are then allowed to absorb some moisture by keeping them in "sweating chambers" for a few hours. The nuts are then graded and packed. For export trade they are packed in tin cans, after exhausting the air inside. Some also pack the kernels in carbon dioxide. The kernels marketed within the country are packed in old tins which are not hermetically sealed air-tight, or in gunnies.

PESTS AND DISEASES :—The only serious malady of the cashew seems to be the die-back which is particularly bad in neglected plantations or on shallow or rocky ground. An effective remedy for this is not so far known.

List of References

1. Agricultural Marketing Adviser to the Government of India, Report on the Marketing of Cashewnuts in India, Mark. Series No. 47, 1944.
2. Naik, K. C.—Fruit Personalities—Cashew, *Mezhichelvam* (Tamil), Madras, March, 1946.

12. COUNTRY ALMOND (*Terminalia catappa*)

This is also sometimes known as the Indian almond. It is a handsome and large tree of high ornamental value, grown in many home compounds. It bears fruits, the pulp of which is edible and enclosing a thin kernel which is also eaten with great relish. The propagation is by seed. The fruits are ready for harvest in April-May and again in October-November.

13. MUSK MELON (*Cucumis melo*)

The sandy bed of Pennar river near Sidhout and Chennur in Cuddapah district are the reputed and chief centres of musk melon cultivation. A prized fruit in early and mid-summer in Madras markets and in most parts of the Ceded Districts and neighbouring areas, these musk melons are also popularly known as Cuddapah melons. However, the fruit is grown, though to a lesser extent, far beyond Cuddapah such as on river beds in Kurnool, near Tadpatri in Anantapur District and occasionally even in Chittoor and other parts of the Ceded Districts.

At Chennur and Sidhout centres, the cultivation of musk melons starts in the middle of December every year. The cultivator does not have to pay for the land he uses for the crop or any kind of tax to the Government for producing this crop on the river bed. Anyone is free to mark out and utilise as much area as he chooses from the sandy stretches.

CLIMATE AND SOIL :—The season for growing this crop is restricted to the driest period of the year from December to June.

A high temperature and low relative humidity at the fruit maturity season is believed to be essential to impart quality, and it is due to these climatic features that Cuddapah melons in particular have acquired a reputation. At the same time, it is the climate that makes melon growing in Cuddapah one of the most risky ventures to the producer. A downpour of pre-monsoon rain during the crop growing season and a consequent rise of water in the river destroys the entire crop on which the poor grower has expended all his time, energy and resources. Even a chance shower may cause severe injury to the vines and fruits, such as to destroy all chances of making a profit out of the crop. Precarious though it is, depending on the vicissitudes of weather, the melon grower is by no means deterred from his avocation, as fair crop years usually are more frequent than failures.

Though a pure sand medium, with no apparent variations, the elevation of the river bed as well as the distance from the water stream have an important influence on the culture and quality of the melons. Deeper trenches for planting of vines are naturally rendered necessary as the site is selected away from the stream and on an elevated part of the river bed. Where the water table recedes quickly and the melon roots are unable to tap the moisture in lower layers, water has to be led from the higher reaches of the river through specially formed channels. Such channels are made generally about 20 days before the harvest and reach close to the planted area, and from these channels water reaches the root zone merely by seepage through the lower sandy layers. Melons grown on the upper regions on the river bed are said to be superior in quality, though most producers prefer the lower regions because of lower cultivation costs in such regions.

VARIETIES

Although a dozen varieties are under cultivation, those that are fancied for large scale cultivation are only three, viz., Bathasa, Sherbat Anar and Shiranjir.

1. BATHASA:—A medium sized fruit, roundish oblate, having light yellow peel colour with a greenish patch near the stalk end, this has two distinct forms or varieties, distinguished by flesh colour—one having green and the other white and sweeter flesh. Both the Bathasa White and Bathasa Green are said to be multiplied true to the parental varieties to a large extent, by seed. Bathasa fruits are not netted and are considered by many to be the

best of the Cuddapah melons. It is acclaimed to be the best yielder with an average of two to three fruits per plant, as against the maximum of two fruits only in other varieties.

2. SHERBAT ANAR :—Bears medium sized, round to roundish oblate fruits, slightly larger than Bathasa and has a lemon yellow peel colour. The flesh is cream white and the fruits may be netted or smooth. Fruits of this variety are said to be insipid in the case of early sowings, while those from the later sowings are believed to be of high quality. Though relatively a less prolific variety, Sherbat Anar enjoys a better market, as it is reported to keep better than the Bathasa and Shiranjir.

3. SHIRANJIR :—Fruits of this rank only next to the two varieties mentioned above in quality. The shape and size of these fruits are intermediate between the two preceding varieties, it being less flat than Bathasa and smaller than Sherbat Anar. Peel colour is yellow with green marks, while the flesh is leaf green. The fruits are not netted. Jam Khirni is synonymous or closely allied to this variety.

4. HINGAN :—This is not a superior fruit, but possesses a long keeping quality and therefore enjoys some importance as an exportable fruit even upto Calcutta. It is a long fruit, rather oval to oblong in shape with reddish peel and with reddish or white flesh colour, the latter being sweeter in taste. Fruits are netted and can be kept for about 10 days, while the other varieties mentioned above keep hardly for two to four days.

5. BUDUMI :—This variety is even less known for quality than the Hingan. Because of its largest sized fruits it has, however, a little export value notwithstanding its poor quality.

It is necessary to state that occasionally immature fruits of Sherbat Anar, Hingan and Budumi may be bitter in taste, but the bitterness seems to disappear since no ripe fruit has been found to possess the bitter principle.

SOWING AND MANURING :—Seeds collected from choice fruits in the previous year, and grown in Sidhout and Chennur areas alone are preferred for sowing, the belief being that seeds obtained from elsewhere yield fruits of low quality. The seeds are sown close together in a flat bed near the stream. In about six days the seedlings develop a couple of leaves, with a stem of about one inch high. They are then ready for transplanting.

By this time trenches, about 12" to 18" wide and roughly 100 ft. to 200 ft. long, with a depth ranging from two inches to about two feet according to the depth of the water table, are prepared with a spacing of about 6 ft. between the trenches. The trenches have straight sides and a flat bottom. In the centre of these trenches and at every second feet, a handful of cattle manure is placed first, and over it a thin layer of sand is thrown. In the centre of this heap is then made an opening by hand, where the 6-day-old seedling is placed, and some sand is thrown over and around it to complete the planting.

About four days after the planting, a circle is made by the forefinger around the seedling, roughly 6 to 9 inches away from the stem. Over this ring and also within it is spread a mixture of equal quantities of bat guano and of neem or groundnut cake, or the former plus a manurial mixture of commercial firms like those of Messrs. Parry & Co., or Messrs. Shaw Wallace & Co. One of these commercial manurial mixtures show on analysis, 15% nitrogen, 7% phosphoric acid and 3% potash. The quantity of the mixture including bat guano added to a plant is about 2 table-spoonfuls only. Immediately after the manure is spread, a man walks inside the trench, covering up the manure on either side of the plants with sand by his feet. This light covering up with sand may be done by hand also.

Five days later another application of manure is made. For this, two small pits are dug on either side of the plant parallel to the sides of the trench. The pits are each about three inches long and as broad, with depths ranging from two to four inches according to the depth of water table and the spread of the roots. They are dug out by hand with the aid of a small flat iron or wooden piece. The pits are to be more or less in the centre between the plant row and the trench sides. In these pits are placed a handful of cattle manure first, and over it is thrown about two tablespoonfuls of the manurial mixture made up of equal quantities of bat guano and of cake, or the former and Parry's or Shaw Wallace's mixtures. The pits are immediately covered with sand.

On the following day earthing up of the plants is done by drawing sand towards the plants from either side to form a ridge across the trench, with the plant standing in the centre of the ridge.

Yet another and last application of manure follows seven to eight days later. In this case pits are prepared as for the preceding application but in the centre of the trench and of the two contiguously standing plants on either side of the ridge. The same manure and in similar quantities are applied as in the preceding instance. Covering with sand is then attended to. Use of groundnut cake is prohibited for melons in Sidhout area under the Pest Act for the control of a fly—*Stomaxys calcitraus,* which attacks cattle, making them restless. Groundnut cake is found to emit an offensive smell in the course of its decomposition, besides helping in the breeding of the above mentioned pest.

SUBSEQUENT CULTURE

A week or 10 days after the above application or roughly a month after sowing when the vines may be about 18" long, trenches are levelled up to bring them flush with the surface of the river bed. This is only possible when trenches are shallow, upto only a few inches depth. Where they are deeper, such levelling will lead to burying of a considerable length of plant stem under sand. In such cases, therefore, the grower removes the surplus soil from the edge of terraces and spreads them between the trenches to form a mound, on either sides of which the vines trail up on a slanting position.

Each plant may produce about 8 shoots or trailing vine branches. Half of these are allowed to trail on one side of the trench and half on the other side.

Left to themselves, the vines may spread much farther than is convenient, and perhaps such spontaneous extension growth may not also be conducive to fruitfulness. About 10 days after levelling, the growers therefore pinch off the terminals of all the trailing shoots, roughly to remove an inch of the apex. This induces emergence of side shoots, and perhaps the blossom crop is also increased. To prevent the vines being dislodged by wind the terminal ends of vines may be buried in sand.

CROPPING

Blossoms appear on an average in 40 days from the date of sowing the seeds. By the time the pinching is done, therefore, some plants will have already produced blossom. It is estimated that each plant may have about 40 flowers on the average, of which a majority (upto 30) may shed, possibly because they are staminates, thus leaving only 10 to 12 to set fruits on each plant.

About 10 per cent. of the plants also are reported to be pure males, incapable of producing any fruit.

Even out of 10 or 12 flowers that set fruits on each plant, not more than 2 or 3 reach the stage of final harvest. The harvest commences in 70 to 80 days from the date of sowing. There is a belief that earlier sown crops, i.e., those sown by about the beginning of January have a longer duration than those sown later in the warmer period. Although the earlier harvests are generally more remunerative, the fruits of the latter harvests are accepted on all hands as superior in taste. The harvests last for about 20 days only in one batch of sowings. The picking is done for local consumption only when fruits separate from the stalk. For distant markets, however, the picking has to be advanced, and is done by cutting off the stalk close to the fruit. These fruits are not as tasty as those which have got naturally separated from the stem.

14. WATER MELON (*Citrullus vulgaris*)

Apart from the exterior appearance and colour as well as from the edible qualities, water melons differ from the musk melons in seed colour. While the latter have only white seeds, the former have either black or red seeds.

Water melons are grown both in sandy beds along with musk melons and also in garden lands. It is, however, claimed that the fruit raised in sandy river beds are definitely superior in taste to those raised elsewhere.

VARIETIES :—Two varieties are recognised in Cuddapah.

1. SURAI :—Bears longish fruits, with a leafy green colour on the exterior.

2. GOTA :—Bears round fruits and has a darker peel colour than the Surai and also a deeper red flesh colour.

Both varieties may produce seeds having black or reddish coats. The flesh colour in both is red or reddish, but in both the immature fruits are white or whitish. Deep red colour is the best and this seems to be partly an indication of proper maturation and partly of good soil and culture.

The method of water melon culture is identical to that described under musk melons in so far as Chennur and Sidhout practices are concerned. On the garden lands, water melons do not receive any special treatment except those normally given for raising gourds and such vegetables.

It is, however, common to select a slightly higher site on the river bed for water melons than for the musk melons. Harvesting of water melons is commenced in three months, and may be completed in about 15 days. Water melons keep for about four days, but Gota is said to keep sometimes upto six days.

The harvest commences when the fruits on tapping produce a thud sound.

Like the musk melons, the water melon is essentially a table fruit, though it is also crushed to give a delicious and refreshing beverage during the summer. The water melon can also be pickled and used for preparing some kinds of sweets. It is grown in river beds with the musk melon in the Ceded Districts and also in gardens and sandy banks all over the plains of South India. However, the irrigated water melons in garden lands are distinctly inferior in quality and have less granular flesh.

Only the sweet edible forms of water melons are grown commercially, although a few inedible bitter forms exist. The former are not clearly defined in respect of varieties, and it is not definitely known if any of the so-called varieties can be depended upon to breed true to the selected parents. In the Ceded districts, a variety possessing some reputation, though not commercially cultivated, is the Mecca tarbuz, which has pink flesh and black seeds. It is said to keep well even for several months after harvest. The commonly cultivated water melons do not keep more than 2 to 4 weeks.

The cultivation of water melons in Cuddapah and Kurnool is similar to that of the musk melons. The former, however, take 75 to 80 days from seed to mature fruits. On garden lands, the harvests are obtained generally from April to June.

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ERRATA

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2. Para 3, Line 5—29 to read as 3.
73. List of References—2. „ to read as Naik, K. C.
125. Fruit markedly long to read as Fruit Markedly Long.
129. The last fruit in the Fig. should bear the number X-5 below
135. XVI-2, Line 2—Puri to read as Pairi.
137. XXI-2, Line 2—BURMODEILLA to read as BURMODILLA.
140. XXIV—PEEDA to read as PEDDA.
154. Pl. VI to be deleted in Fig.
166. Fig. 45—No. 2 is missing in the Fig.
281. Fig. 71—Vamankeli to read as Vamanakeli.
288. Para 3, Line 9, the to be deleted.

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